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A WATER POWER ELECTRIC TRANSMISSION plant has recently been completed at Cascade, B. C., on the Kettle River. Cascade is about 30 miles due west from Rossland. The power is to be transmitted to Phoenix, about 21 miles, where the principal copper mines of the Boundary District are located. The Kettle River passes through a rocky gorge with a fall of 120 ft. and at the head of the gorge a dam has been built. It is a rock-filled timber crib structure, 50 ft. high at the center and 400 ft. in length. The dam raises the water 35 ft. above the ordinary level, making a total available head of 156 ft. From the dam the water is carried through a cut and tunnel driven through solid rock a distance of 1,135 ft. At the end of this rock cutting are located bulkheads and gates controlling the entry of the water to a 7-ft. wood stave pipe, 1,400 ft. long. At the top of the bluff this wooden pipe is connected to a riveted steel pipe extending down to the power house. The equipment consists of three 36-in. turbines made by S. Morgan Smith, of York, Pa., direct-connected to Westinghouse 3-phase generators of 750 KW. capacity. These machines deliver current at 2,200 volts, running at 300 revs. per min. Escher-Wyss governors are used. The current is delivered to a bank of nine Westinghouse, oil-cooled transformers, which raise the potential to 20,000 volts, and these are connected to the transmission circuit, consisting of a double pole line, each carrying three No. 3 B. & S. copper wires. The total investment in the entire plant is reported as about $500,000, or about $161 per HP. of capacity developed with the present equipment (about 3,100 HP.). The flow of the stream is sufficient for double this power. The plant was built by the Cascade Water Power & Light Co., which is owned by the London & British Columbia Goldfields Co., Ltd. The transmission line was built under the direction of Wm. Anderson, the local company's engineer. The whole installation was made under the direction of Mr. W. C. McConnon, Constructing Engineer in Charge for the Westinghouse Electric & Mfg. Co., to whom we are indebted for the above information.

A PORTLAND CEMENT PLANT having a daily capacity of 4,000 barrels of cement is to be built by the Illinois Steel Co. at Indiana Harbor, Ind., at a present cost of $1,500,000 and an ultimate cost of $3,000,000. It will be known as the Buffington plant, and will be in operation in about 12 months, employing 400 to 500 men. The buildings will be of steel and concrete, and the present plans include the following: Raw material building, 180 x 130 ft.; burner or kiln building, 120 x 240 ft.; finishing mill, 70 x 240 ft.; two storage warehouses, 120 x 350 ft., each of 400,000 barrels capacity. Mr. Edward M. Hagar is Manager of the Cement Department.

A DRAINAGE LAW was passed by the recent session of the New Jersey legislature. It provides for the appointment by the courts of drainage commissioners on petition of ten or more citizens who deem it necessary for the public health that any pond, artificial reservoir, marsh, swamp, bog, meadow or low or wet lands should be drained. Such commissions would consist of three members, one of whom would be a civil engineer. There must be a hearing on the petition to the court, and hearings by the commission before beginning drainage work. The cost of drainage would be assessed upon property benefited, and any excess of cost over benefits would be met by the municipality in which the work was located. After completion, drainage works would be under the charge and maintained at the expense of the municipality.

A NEW ROAD IMPROVEMENT ACT has been passed by the New Jersey legislature. It authorizes any county, city, township, town, borough or village in the state to initiate proceedings for the permanent improvements of highways, and makes it mandatory for the governing bodies of the same to carry out such improvements when petitioned for by the owners of two-thirds of the frontage on any road, provided that the road to be improved is at least a mile in length, or a continuation of a road already improved. All such road work is to be done by the county board of supervisors or the city council or other local governing body, as the case may be, but the plans and specifications must be approved by the State Commissioner of Roads. The cost of work done under this act will be met one-third by the state and the balance by the county or other minor civil division involved, except that where property-owners initiate the work they shall relieve the local unit of 10% of the cost, and providing that the state pays not over $400,000 in any one year, and the county, city, or town not over 0.5% of its assessed valuation. Where all the owners are willing to unite and pay the full cost of the improvement the work may be done in accordance with the act in all other respects. The act provides for inspectors on each contract, and after one stretch of road has been built, for a county or town supervisor of roads, as the case may be.

ROAD MAKING IN NOVA SCOTIA is discussed as follows in the annual report of Martin Murphy, D. Sc., Provincial Government Engineer:

Generally speaking, the roads of Nova Scotia do not, in an economical sense, require a Telford pavement or a macadamized surface, as has been so often advocated. It is very doubtful if either of these systems would suit in clayey districts, where drainage is difficult, and where the roads would be prone to heave by the frost. In such places as the city of Halifax, or other towns in the province where they can be properly cut down, and where there is a skilled supervisor to direct the work, either system may be desirable. But for general repairs on many of our country roads, their adoption would not be advisable.

What is wanted in this province is a system which will utilize material near at hand, suitable for the purpose, by the adoption of a thorough system of drainage. In places where gravel or small stones can be had, it may be often economical to cart such material quite a distance, but where they cannot be procured, gravelly clay can be made use of. If our clay roads are well formed, not too wide, yet convenient for passing vehicles, well rounded, high in the center, with no ruts or holes to retain water, and ample drainage, for a great portion of the year the surface will be fairly good. Clay roads require frequent attention, especially in wet weather, to keep ruts from forming pools. Drainage in this case requires special attention.

If a covering of gravel, or better material than ordinary clay, can be had, it ought to be used. Still, clay roads can be kept passable for teams with a slight covering of gravel or gritty clay throughout most of the year.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision between a passenger and a freight train at Red House, N. Y., on the Erie Ry., on April 20. Eight persons were killed in the wreck and fire of the ruins, and nearly a dozen others injured. While the cause of the accident is not yet clearly determined, it is thought to be that a towerman gave a premature clear signal to the passenger train while a freight train was leaving the main line for a siding.

A GAS EXPLOSION IN MINE No. 77 of the Kansas & Texas Coal Co., at Carbon, I. T., on April 12, killed five men and severely burned two more. Seventy-five men were in the mine at the time.

A PECULIAR ACCIDENT occurred in Dayton, O., on April 12. A terra cotta block fell to the sidewalk from the sixth story of the Reibold Building, a structure about 125 ft. in height, of steel skeleton construction, built eight or nine years ago. The day being Sunday, few people were passing at the time and no one was injured. An investigation made by a prominent architect and an experienced brick mason showed that the face only of the piece of terra cotta had fallen, the rear part of the block remaining in place. The opinion of the experts as to the cause of the fall was as follows:

Our opinion is that the block in question prior to its being built in had a flaw or imperfection through which the water and frost worked and by alternate freezing and thawing and consequent expansion and contraction loosened the face, permitting it to work out and drop, leaving the balance of the block intact.

A DRAWBRIDGE ACCIDENT occurred at Chicago on April 16, when an electric car ran onto the Wells St. bridge just as the bridge was being closed after the passage of a steamer. The bridge is of the center-pier swing type, and is a double-deck structure, carrying the Northwestern Elevated Ry. on the upper deck. The only protection when the bridge is open is a light chain across the roadway, but this appears not to have been stretched at the time. The accident occurred about 8 p. m. The vestibule was crushed by the end post and the car was thrown transversely across the roadway. None of the 25 passengers were injured, but traffic on the street and elevated lines was blocked for about an hour, while the car was being pulled clear of the trusses.

THE FAILURE OF A CONCRETE FLOOR in the Johnson Electric Co.'s new building at Milwaukee, Wis., was described in our issue of April 9, and in reply to an enquiry we have the following letter from Mr. Ernest L. Ransome (of Ransome, Smith & Co.), New York, in regard to the accident:

In my judgment the accident was undoubtedly due to the failure of the brick work. So far as was revealed by the exposed work after the failure there was no bond between the inner 8-in. thickness of wall and the outer thickness of same, 18 ins. I personally counted 15 tiers without seeing a single header to connect these two thicknesses. The mortar of the brick work was without Portland cement, which for winter work was a grave defect. There had apparently been no set to this mortar; its cohesion was extremely slight and its adhesion to the bricks even less. So much as to the cause of the failure. As to further results of the investigation I do not feel that at the present time I am at liberty to disclose them.

A LOCOMOTIVE "COMBINE" has been formed in Great Britain by the consolidation of three of the large locomotive building firms in Glasgow, Scotland, under the name of the North British Locomotive Co., having a capital stock of $10,000,000. These firms are as follows: Neilson, Reid & Co. (Hyde Park Locomotive Works), Dubs & Co. (Glasgow Locomotive Works), and Sharp, Stewart & Co. (Atlas Works). The three plants have a capacity of about 600 locomotives annually, and employ over 7,000 men. The business of Neilson, Reid & Co. was established in 1837 by Mr. James B. Neilson (Manager of the Sharp, Stewart & Co. works) under the name of Neilson & Co. In 1863 Mr. James Reid joined the firm and since his death in 1894 his four sons have constituted the firm. The business of Dubs & Co. was established in 1863 by Mr. Henry Dubs, who had withdrawn from Neilson & Co. The business of Sharp, Stewart & Co. was established in Manchester in 1834, but in 1888 it was amalgamated with the Clyde Locomotive Co. and transferred to Glasgow.

FIRE TUBES IN BOILERS were the subject of a recent investigation by Mr. C. Bach, on the occasion of a boiler accident in which the rear head blew out due to loosening of the tubes in the sheet. He concludes that it is important to design fire tubes so that they may be elastic longitudinally; that in such cases where the tubes are likely to expand more than the shell, and can thus put an outward pressure on the heads, the tubes should be heated when being fastened in place; and that, as a general rule, expanding and beading the ends of the tubes is a sufficient fastening. He also concludes, with special reference to the accident case then under investigation, that the practice of setting boiler heads with the convex side inward (to make machine-riveting possible) is likely to involve danger, and further, that the weakening of tube ends by corrosion is a matter which the inspector should determine.

THE TRANSANDINE RY., to connect the railway systems of Chili and Argentine lacks only 35 kilometers of completion, according to a descriptive article in the "Railway Review." The summit of the Andes range is to be pierced by a tunnel 3,400 meters in length. The line on the Argentine side is completed almost to the portal of this tunnel, and the section still to be built is on the Chilean side. The broad-gage (5 ft. 6 ins.) line of the Argentine Ry. terminates at Mendoza, 170 kilometers east of the summit, and the line from here is of meter gage. The Abt rack rail is used to surmount the steeper grades on the line.

THE DOME FRAMING OF THE CHICAGO POST OFFICE BUILDING.

The Chicago post office building now approaching completion, undoubtedly ranks as one of the handsomest and also one of the largest buildings ever erected in the United States for Government purposes. As will be seen from the perspective drawing, Fig. 1, the most pronounced architectural feature of this building is a lofty central dome. This dome rises some 300 ft. above the street surface and is 100 ft. in its greatest diameter. It is constructed of a steel framework covered with an integument of granite and brick masonry, and the general details of this construction are shown by the accompanying views and drawings, which have been furnished to us by the engineer, Mr. F. W. Lepper, U. S. Treasury Department, Washington, D. C.

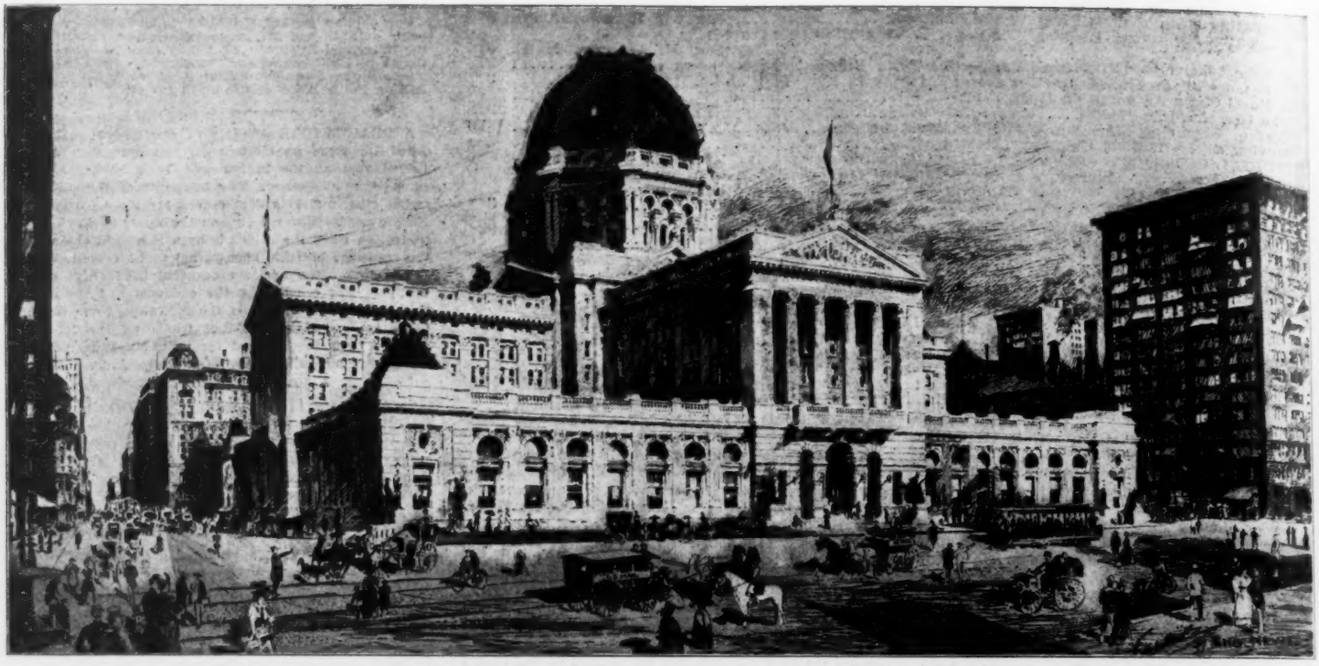

FIG. 1. GENERAL VIEW OF CHICAGO POST OFFICE BUILDING.
Henry Ives Cobb, Chicago, Ill., Architect; F. W. Lepper, Structural Engineer, U. S. Treasury Department, Washington, D. C.

To understand clearly the dome construction a brief description of the main building is necessary. The ground plan of the building is 400 × 286 ft., and as will be seen from Fig. 1, this whole area is covered by a rectangular structure two stories in height. A cruciform building with four wings 96 ft. wide rises from the two-story structure to a height of six stories more. The dome is located at the center of the cross-shaped building and extends some 153 ft. higher. Stated exactly, the heights from the sidewalk level are: To the top of the parapet wall of the rectangular portion, 53 ft. 1 in.; to the roof of the cruciform portion, 128 ft. 5 ins., and to the highest point of the dome, 297 ft. The aggregate floor area of the building, including the dome, is 660,000 sq. ft.

The framing of the main building, which required about 10,000 tons of steel, calls for but little comment. The columns are of Z-bar type and the floor framing is a rectangular arrangement of plate girders and I-beams with square connections. Aside from its heavy character, the steel skeleton of the main building is in nowise of unusual form, and is sufficiently explained by the general view, Fig. 2. The building is neither of the solid masonry nor of the strictly skeleton type, for while each story is carried independently, the walls are about 3 ft. thick, of heavy ashlar, with solid brick backing. Great pains were taken to have all granite work thoroughly anchored and all steel work in masonry perfectly embedded in cement, the wall columns in all cases being filled with concrete. Open joints were provided in the masonry wherever there was a possibility of settlement throwing undue loads on a steel member. The only special details were those required in anchoring the covering to the steel frame. One of these details is shown by Fig. 3, and it gives a very fair notion of the character of the means resorted to in this kind of work.

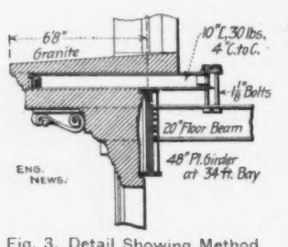

Fig. 3. Detail Showing Method of Anchoring Eighth-Story Cornice to Steel Framing.

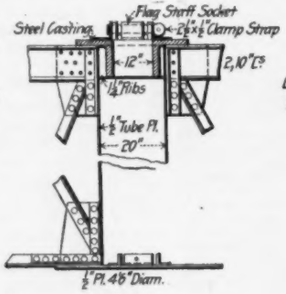

Fig. 5. Detail of Connections at Apex of Dome.

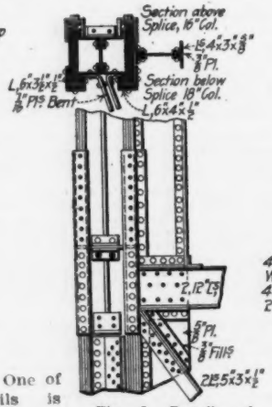

Fig. 6. Details of Column Splice at B, Fig. 4.

It will be observed from Fig. 4 that the framing of the dome was made in a great measure independent of the main building framing. The dome framing is octagonal in form and is continuous from foundation to apex. The columns are set radially in pairs at the angles of the octagon, and are rigidly braced together by vertical frames and X-bracing. The lower story of each outer column was proportioned for a load of 1,000 tons at 12,000 lbs. per sq. in. At each floor level an octagonal framework joins the eight pairs of columns and binds them together into a rigid tower. The roof or dome proper is formed of eight radial curved trusses connecting at the apex with a steel plate ring. Details of this apex connection are shown by Fig. 5. Just below the roof framing the dome is stiffened by two deep trusses which carry the beams of the upper three floors. The location and character of these trusses are clearly shown by the diagonal section and the plan in Fig. 4. A similar set of trusses carries the eleventh, twelfth and thirteenth floors. Below these, at about the level of the ninth floor, there is an interior dome framework. The other general details of the dome framing are clearly indicated by the drawings of Fig. 4.

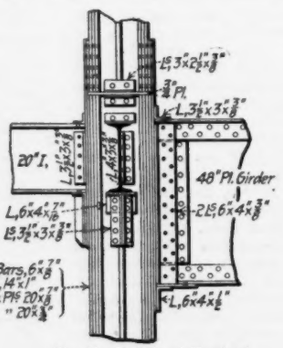

Fig. 7. Detail of Typical Column and Girder Connection.

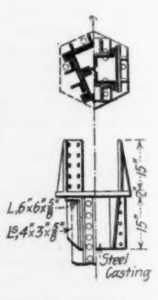

Fig. 8. Detail of Column Connections at 12th and 15th Floors.

A few of the special details call for brief mention. Fig. 6 shows the column splice at the tenth floor level, and Fig. 7 shows the typical column and girder connections. At the twelfth and fifteenth floors the columns are changed from the radial position to simplify the connections of the large dome trusses, this change being effected by the special splice construction shown by Fig. 8. Fig. 9 is a view of the dome framing practically complete, and Fig. 10 shows the dome with its covering nearly all in place.

From the nature of the plans there was little

difficulty in providing against wind stresses in the eight-storied portion. The columns are in two, sometimes three, story lengths, with the joints staggered, and the stiffness gained by this means was supplemented by a number of 28-in. plate and angle knee braces and by flats or channels riveted to the tops of floor beams. The dome framing required greater precautions against vi-

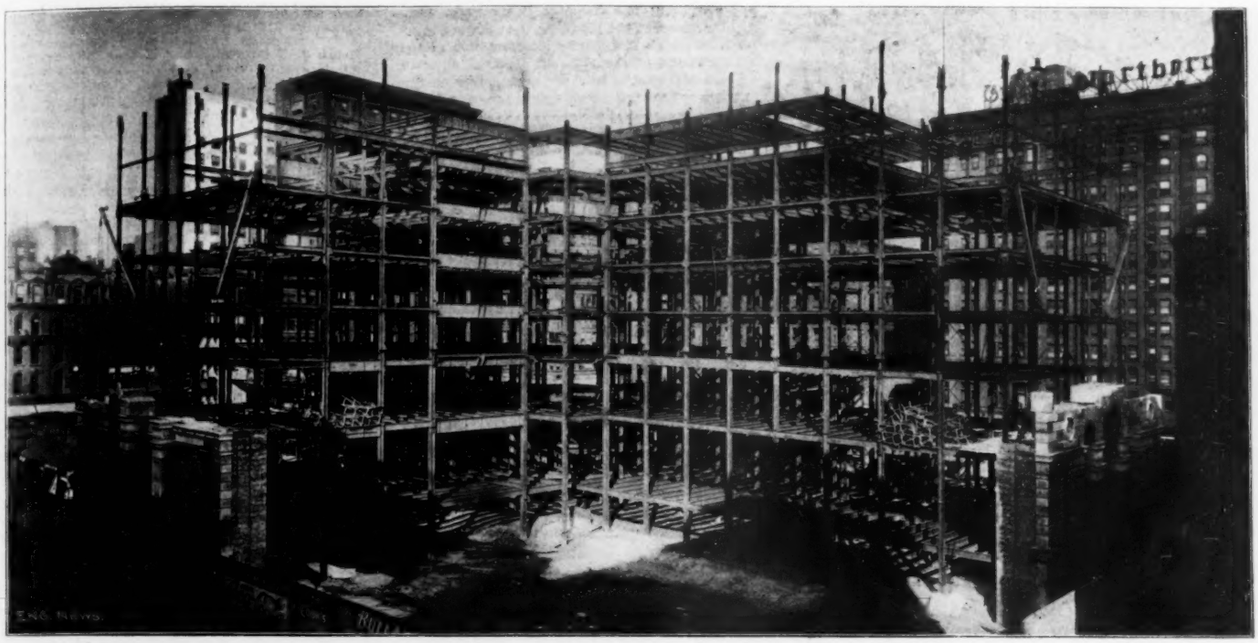

FIG. 2. VIEW SHOWING STEEL SKELETON FOR MAIN STRUCTURE OF CHICAGO POST OFFICE.

bration, especially between the ninth and eleventh floors. Diagonals were used wherever the architectural features would permit, though the portals and columns, in connection with the bracing in floors and sides of octagon, were proportioned to transmit a wind pressure of 30 lbs. per sq. ft., above the eighth story roof, directly to the ground, without depending to a great extent upon the rigidity of the main portion of the building. The upper parts of the main buttresses of the dome are supported by the brackets inside of them at the tenth floor level; below this point they are carried on beams and girders.

Henry Ives Cobb is the architect of the building and John Pierce, of New York city, is the general contractor for the superstructure and interior finish.

A WATER-WORKS APPRAISAL AT MOBILE, ALA.

One of the most interesting and important cases of the valuation of water-works plants which are now being undertaken where cities and towns desire to exercise their rights to purchase the property of private water companies, is that recently concluded at Mobile, Ala., a city of about 40,000 inhabitants.

In 1888, the Bienville Water Supply Co., now owned by members of the firm of R. D. Wood & Co., of Philadelphia, built a water-works system under a charter which expires in 1906. The supply is taken from Clear Creek at a point about five miles from the city limits, and is pumped through a 24-in. main to a reservoir of 10,000,000 gallons capacity by two Holly pumps, each of 6,000,000 gallons daily capacity. There are 47 miles of pipe in the distribution system. The company claimed an exclusive franchise, but the United States Courts held that the exclusive feature was invalid. At different times the city made tentative propositions to purchase the works, but was unwilling to pay such a price as the company demanded, and no definite steps were taken. Meanwhile various complaints were made against the company, principally to the effect that its rates were too high, and that it did not extend its mains fast enough in the outlying districts; on the other hand, the company held that the city refused to pay for the additional hydrants which would have been required on such extensions. There was no complaint as to quality of water, and very little as to fire pressure.

After various indefinite negotiations with the water company, and without any serious attempt to arbitrate the value of the works, the city finally voted in 1897 to build a water-works system of its own, at a cost not exceeding $500,000. This was constructed in 1900, the pipe system of the Bienville company being practically paralleled throughout, as well as additional mileage laid. The supply was taken from another creek than that supplying the company's works. This action, however, has resulted in depreciating the value of both the municipal and the private plant, as the city could not keep the rates high enough to pay fixed charges and operating expenses. The company took out all its meters, and the low rates and fierce competition for consumers resulted in excessive use and waste of water, so that the demand upon the city works is now approaching the limit of the source of supply. Under such conditions, and as the result of two years of operation, it seems to be necessary after all for the city to provide for the purchase of the company's works.

A commission for the appraisal of the value of these works was therefore appointed in 1902, under recommendation of a Council committee, it being provided that the appraisal should be advisory, and not binding upon either the company or the city. The city appointed its Superintendent of Water-Works, Mr. M. F. Sullivan, as its expert engineer; and the Bienville Water Supply Co. appointed Mr. John W. Hill, M. Am. Soc. C. E., of Cincinnati, O. (Chief Engineer of the Bureau of Filtration, of Philadelphia). These gentlemen met in October, and appointed Mr. John W. Alvord, M. Am. Soc. C. E., Consulting Engineer, of Chicago, as the third member of the Board. The Board made a careful examination of the plant and appurtenances, and in January, 1903, presented its report, placing the value of the Bienville company's plant to the city at $606,689. It was further concluded that with reasonable rates and a restriction of waste, the city can pay interest and expenses on the value of both plants.

An abstract of the report is given below, together with abstracts of supplementary letters from each of the three members of the Board of Appraisal:

Report on Appraisal of Value of Property of Bienville Water Supply Co., Mobile, Ala.

METHOD OF ARRIVING AT VALUE.

In deciding upon the method of arriving at the value of the property of the Bienville Water Supply Co., your board were very largely governed by the text of the decision of the Supreme Court of the United States in the case of the Bienville Water Supply Co. vs. the City of Mobile and John Curtis Bush, mayor thereof, which decision was rendered June 2, 1902, and has seemed to this board to be the most authorative light which it could obtain upon the question before it.

In the latter part of that decision it is stated:

Obviously, for the several constitutional provisions which are quoted in the statement of facts, it was intended that the legislature should have the right of revocation and amendment, and that whoever took a charter should take it subject to that right. To what should such revocation or amendment extend, the possible rights of a corporation grouped themselves into three classes: (1) the right to the tangible property which it may acquire; (2) the right to do the specific things which are named in the charter, and (3) the right to exclude others from doing like things.

It has been held that the right of revocation or amendment carries with it no right to appropriate the tangible property belonging to the corporation. As said by Chief Justice Waite, speaking of the power of amendment, in Sinking Fund cases (99 U. S., 700, 720): "All agree that it cannot be used to take away property already acquired under the operations of the charter or to deprive the corporation of the fruits actually reduced to possession, of contracts lawfully made.

In reviewing the above language of the Supreme Court your board came to the conclusion that it was the intention of that tribunal that whatever might be the results flowing from its decision as to exclusive rights, as affecting the commercial values of a public service corporation, it was not its intention in denying such exclusive rights to destroy the value of the tangible property which the company might possess.

Whatever then might be the views of the city of Mobile as to the present commercial value of the company's plant or the necessities which the present condition of competition have forced upon the Bienville Water Supply Co., it seems clear to this board that it is their right to fix the value of the tangible property of the company, that is to say, its pipes, its pumps, lands, buildings and other appurtenances, together with existing contracts already entered into, in accordance with the expressed opinion of the Supreme Court above quoted.

For the purpose of getting at the value of the company's plant as it exists to-day, the following method was adopted: A careful estimate was first made, item by item, of the cost of reproducing the plant in its entirety at the present prices of material and labor, taking into due consideration the local conditions in the city of Mobile as to cheap labor, lumber and certain other commodities. After the cost of reproducing the plant had thus been determined a careful inquiry was made into the life of each part of the plant and its present condition, from which its depreciation was estimated, item by item, and the aggregate amount of depreciation was deducted from the cost of reproduction before mentioned, giving as the result what may be termed the tangible or physical value of the plant, as follows:

Cost of reproduction of the tangible property at the present time	$689,560
Depreciation of same as it exists at the present time	82,871
Value of the physical or tangible property at the present time	$606,689

FINAL CONSIDERATIONS AS TO THE VALUE OF THE TANGIBLE PROPERTY.

It is the opinion of this board that the entire plant as it stands to-day has a tangible value to the city of Mobile to the amount of $606,689, with the following exceptions:

Mr. M. F. Sullivan, representing the city, objects to the value placed upon the water right of $36,806, and would deduct that from the above estimate.

Mr. Hill contends that a going value of $35,000 for the present business of the company should be added to the total value arrived at, in accordance with the decision in the Kansas City case by Judge Brewer.

The board agrees that should the plant be acquired by the city, that 143,606 lin. ft., or about 27 miles of cast-iron distribution pipe might be removed from the ground and used for further extensions by the city, or sold, as may seem desirable. The estimated cost of removing this pipe from the ground is $11,120. It has been thought that about six miles of this pipe could be profitably relaid by the city extending its system and producing additional revenue. And of the balance of the pipe taken up, a portion might be held in reserve for future extensions, or all might be sold, as may be found desirable. If sold, a further depreciation of about $3 a ton should be allowed, or a total amounting to $8,493, which, added to the cost of removing the pipe before mentioned, amounts to a total of $19,613, which it would be necessary for the city to deduct from the full value of the tangible property in order to realize the value of its investment in combination with the city plant already built. The board has not deducted this amount from the value of the plant, as it is not a deduction which the board's interpretation of the language of the Supreme Court admits, in considering the sale of the property to the city of Mobile.

In the accompanying table the value of a single system of water-works is shown, based upon the present value of money and sinking fund charges for redemption of bonds.

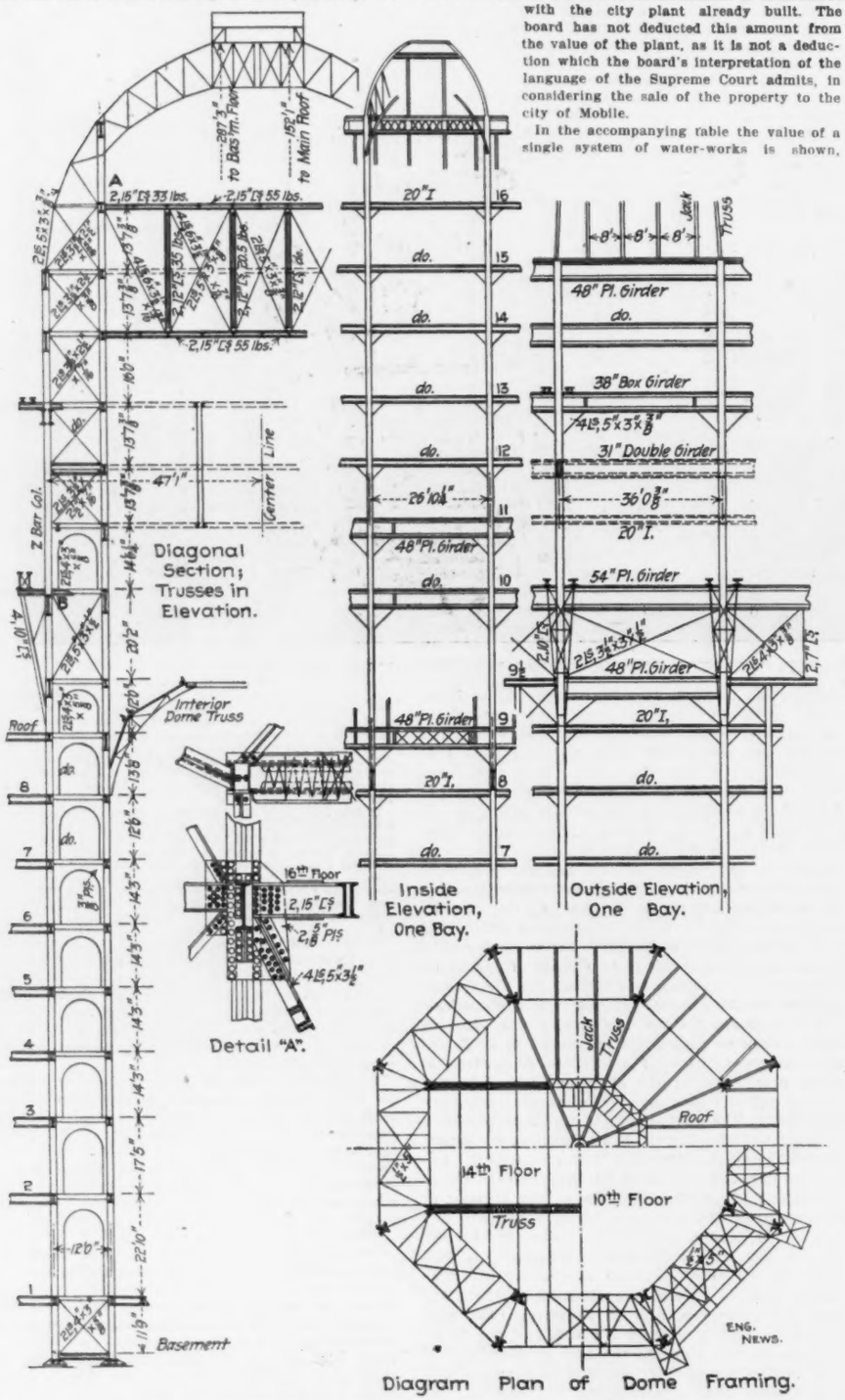

FIG. 4. GENERAL DETAILS OF FRAMING FOR OCTAGONAL DOME.

Financial Statement of Present Worth of Property Based Upon the Removal of Competition and the Distribution of Water to be Limited to One Corporation, Instead of Two, as at Present.	
Net income after deducting:	
Estimated Present Reasonable Daily Consumption.	
40,000 × 105	4,200,000 gallons.
Annual consumption in 1,000 galls.	1,533,000
Annual revenue at 8 cts. per 1,000 galls.	$122,640
Operating and maintenance charge, 22½% of gross income	27,594
Net earnings	$95,046
Total number of taps in use, both works	6,787
Assume half of meters taken over from the Bienville Water Co. to be serviceable, 134 ÷ 2	67
New meters required	6,720
Cost of 6,720 meters installed at $15	$100,800
Cost of placing 67 meters at $6	402
Total	$101,202
Fixed charges at 4% interest, 2.1% sinking fund charge on $101,202, 30 years	6,173
Fixed charges on $750,000 water and sewerage bonds, 4½% interest, 1.58% sinking fund charges for 36 years	45,000
Total fixed charges	$51,173
Net income after deducting:	
(1) Operating and maintenance charge,	
(2) Fixed charges on cost of metering all services	
(3) Fixed charges on $750,000 water and sewer bonds	$43,272
Net income $43,535, capitalized at 6.60% interest and sinking fund charge on 30 years	$655,646

With reference to the said financial statement the following suggestions are made: The present population of Mobile is in round numbers 40,000. An allowance of 105 gallons per capita per day is about one-third the present consumption and waste, and in our opinion is well within the probable consumption after all services have been metered. In localities where consumption of water is less than this, one or two of the following causes operate to reduce the consumption:

1. The quantity of water available is restricted, or.
2. The water rates are so high as to compel the utmost economy on the part of the consumer.

Neither of these causes can for many years, perhaps 50 or more years, be appreciable at Mobile. The Bienville source of water supply alone should be ample for a population of more than twice the present, and the rate of 8 cts. per 1,000 gallons of water metered as an average to all consumers is very low, even when compared with the larger cities of the country. Under these conditions the reduction of consumption to less than 105 gallons per capita per diem can scarcely be expected.

Upon this basis it is estimated that the annual revenue of a single system of water-works and all services metered will be not less (at the present time) than $122,640.

A careful investigation of the cost of operating and maintaining the Bienville Water Supply Co.'s works, after the first three years and prior to starting the city works, of the operating and maintenance charges of the Mobile city works, and of several other works, upon the assumption that all services will be metered, indicates, that of the gross revenue, the operating and maintenance charges will not exceed 22½%. Deducting this amount from the annual revenue leaves a balance of $95,046, to cover the following charges:

1. Fixed charges on the cost of metering 6,787 services.
2. Fixed charges on the water and sewerage bonds issued by the city, 1899.
3. Fixed charges on the purchase price of the property of the Bienville Water Supply Co.

The number of services now in active use from the mains of both systems of water-works is 6,787. Of the 134 water meters owned by the company, it is assumed that half are serviceable, and that the new meters required will average $15 each, installed on the service pipes, and that the cost of placing the Bienville meters will be $6 per meter. Upon this basis, the fixed charges on the cost of metering all services, at 4% for interest and 2.1% for redemption fund, will be $6,173 per annum.

The water-works and sewer bonds of the city aggregate $750,000 at 4½% for interest for 40 years; sinking fund payments to begin in 1900 and continue to 1939, making an annual charge for interest and redemption of $45,600. Deducting this sum and the fixed charges for metering all services from the net revenues leaves a balance of $43,272, an amount which, capitalized at 6.6%, interest and sinking fund charges, will justify an outlay of $655,646 for the immediate purchase of the property of the Bienville Water Supply Co., and extinction of competition in the supply of water to the city. Or, from another point of view, if the company can be guaranteed a monopoly of the business of supplying water to domestic consumers and a perpetual franchise, it can afford to pay this amount to the city solely on account of the water supplied for domestic uses, and acquire the property rights and management of the city works. Thus the combined value of the two works at the present time as a financial investment is shown to be $1,405,646.

In this showing it will be observed that no value whatever has been assumed for the city fire protection, and no allowance has been made for the future growth in consumption of water and revenue. Either or both of these might be given a value and present worth, which could properly be embraced in fixing the value or worth of the Bienville property, from the standpoint of earning capacity of a single system of water-works in Mobile.

In view of the fact that the financial showing is based solely upon revenue or income from domestic users of water, and without an attempt to give a present worth to the business which will follow for the next ten years or more, after the extinction of competition, it is believed that this showing is certainly fair to an intended pur-

chaser, and is an assurance to the city that in paying the company the amount found for the tangible property it will be making a wise and judicious investment.

We have not attempted to discuss the value to the city of the Bienville Water Supply Co.'s property under the present condition of two complete systems of water-works competing for public favor, because this condition is abnormal, ruinous and unfair to both the city and the company, and cannot long be tolerated in a city of the population and prospects of Mobile, and moreover does not and cannot furnish an indication of the true value of the water company's property.

John W. Hill, M. F. Sullivan, John W. Alvord.

Supplementary Letter No. I.—By Mr. John W. Alvord.

THE RELATION OF THE MUNICIPALITY TO PUBLIC SERVICE CORPORATIONS.

The relations of public service corporations to the municipality are in many respects peculiar, and quite different from the relations of corporations to one another, or to individuals. This is a fact not fully appreciated by every one connected with such interests, and ignorance of this peculiarity is the cause of much of the difficulty which arises in considering their relations.

A water company in accepting a franchise to furnish water and fire protection to a municipality for a term of years accepts a grave responsibility, the full effects of which it does not always appreciate. One of these responsibilities is that it may have to furnish water and fire protection at a loss to itself so long as there is need for the same to the area which it supplies. Not only can a water company be prevented from stopping the supply, when it is losing money, but Ohio courts have held that even should its franchise expire, it must not cease to supply water and fire protection to the inhabitants of the municipality until they provide some other method of supply, and upon their failure to do so at the expiration of its franchise, it must continue to render such service even at a loss to itself.

In the case of Weatherly vs. Capital City Water Co. (Ala. 22, So. 140), it was held that a decree of dissolution of a water company does not abrogate the contract of the city with the owners of the water-works for supply, and that pending the winding up of the water company dissolved by an order of court, and whose charter was forfeited, the city has the right to insist upon continued water supply by the statutory trustees.

It would appear from the above that it is no light matter to enter into contract to supply water to a municipality for domestic and fire purposes, and that in assuming such obligation, a company may find itself face to face with complications which never could have been realized at the inception of the enterprise. If it is true that the public utility companies are obliged by action of the courts to assume all of these responsibilities to the public, it must be true that the public undertakes certain responsibilities and duties to the service corporation, and obviously one of the most important of these obligations is that the public should not by any acts of its own, wantonly or wilfully destroy the value of the service company's plant, at least so far as it may be in a useful and efficient condition and have a value for the purpose for which it is intended.

Thus, it is tacitly assumed, I think by all parties at issue that at the expiration of the franchise, some judicious and reasonable arrangement will be made by which the value of the company's plant shall remain intact to be useful either to itself in the continuance of the franchises extended by mutual agreement, or to be taken over by the city for public purposes.

All attempts which have been made on the part of cities to ignore the existence of the physical plant of a public utility company at the termination of the franchise have been set aside by the courts from one cause or another, with but few exceptions, and while it is true that (to the writer's knowledge) no important case has been carried up to the Supreme Court on this point, it is nevertheless a fact that the lower courts have in various ways tried to prevent the destruction of physical values upon the cessation of franchise periods. It is my belief, from a review of all the available information on this point, that public service corporations have no right to wilfully cease to supply water to the public either before or after the termination of their franchise, and that the public has on the other hand no right to entirely ignore at any time the tangible values which the public service company have created.

It will be understood that I do not allude to the commercial value of the company's property, which might or might not be greater than its physical value. The language of the Supreme Court quoted in our report to the city of Mobile would seem to indicate that under certain circumstances the city has a right to destroy certain kinds of values, which we may for the moment call the intangible values which the company may deem itself possessed of. But the thought in all this line of argument is that the actual investment of the company in the pipe, pumps, lands, buildings and other appurtenances, should be so protected that its use would continue to inure to the public good so long as it existed.

THE COMMERCIAL VALUE BASIS.—Unquestionably, many of the citizens of Mobile will feel disappointed because our board did not take the view that the Bienville plant was worth but little because it was not now earning interest upon capital invested. It seems to me that this feature of the case should have had some space in our report in order that the justice of the position which we have taken should be more apparent.

It will be conceded that the value of the company's plant as a revenue producer is exceedingly low at the present moment, and to an outside purchaser other than the city of Mobile, the argument might be advanced that its only value lay in its ability to compel the city of Mobile to purchase it at some future time, either because the city might need an additional source of supply, or because competition rendered it impossible for the city of Mobile to profitably operate its own plant. This is a natural thought to those who have not given this kind of problem much attention, but I think that its fallacy can be clearly shown. Let us look for a moment at the financial condition of the Mobile city water-works. This plant was built at a period when very low prices were prevailing, and at figures which will probably not again be duplicated. It could not now be built at present prices for much less than $1,000,000.

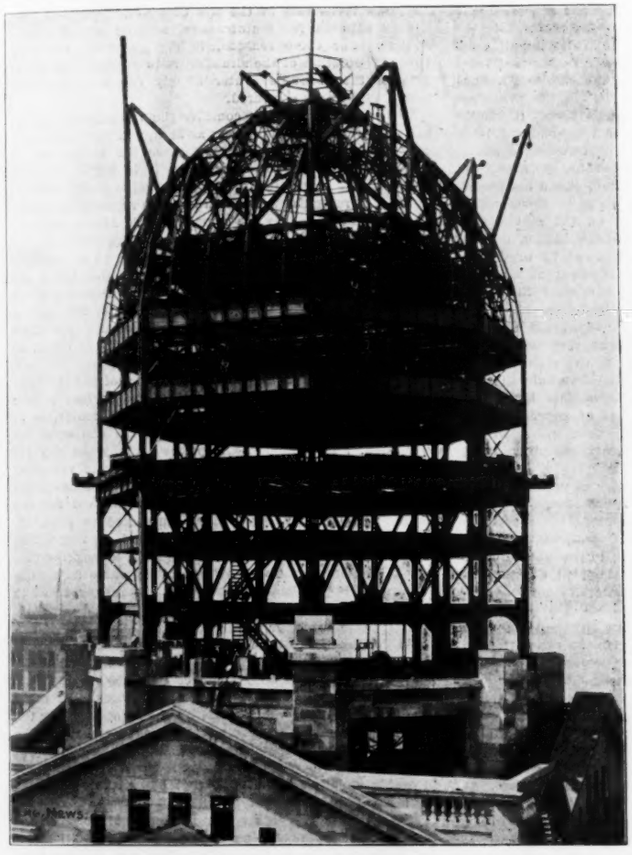

FIG. 9. GENERAL VIEW OF DOME FRAMING COMPLETED.

FIG. 10. GENERAL VIEW OF DOME WITH COVERING NEARLY COMPLETED.

It has pretty fully occupied all of the territory and obtained most of the customers which can be added to it, yet it is only producing a cash revenue of about $43,000 per annum, with operating expenses of $21,000 per annum. If we should allow for a sinking fund of 2% to replace depreciation and provide for renewals we should have a net income not exceeding $12,000 per annum, which at 5% interest would pay interest only on a capital value of $240,000.

During my recent visit to Mobile, I carefully inquired of several of the officials connected with the city what they considered their plant was worth, and in no case did I find that they were willing to place a value of less than $1,000,000 at the present date. I fully concur with these local estimates of value, nor do I attach any weight to the fact that the city plant is not now earning cash interest on that amount, knowing as I do the value of fire service rendered, and believing as I do that the future holds great possibilities, especially by the abolition of competition. By the same process of reasoning I feel that it is not fair to assume that the plant of the Bienville company is worth only the amount it will earn interest upon. It holds possibilities for future development and for future usefulness to the city of Mobile which will certainly render it worth at the present time not less than the value of its tangible property.

The city of Mobile will in the very near future need the Bienville company's water supply, its pumping station, its reservoir, and force main intact, just as they stand, and nearly all of its distribution system can be made at once useful to the city by a rearrangement of its cast-iron pipes which will be neither expensive nor difficult to make, owing to the shallow depth at which they are laid. To assume then that the plant of the Bienville company is but a junk pile or scrap heap is certainly to do violence to a sense of fairness and reasonableness in the situation. I do not believe that any right-minded citizen of Mobile will be willing to take this view of the case on sober second thought. Even if there were no legal opinions and precedents which would seem to strongly point to the injustice of allowing any less value than that contained in our original report, I would still be of the opinion that as a commercial value alone it is a proper and just compensation to the company for its property.

It is true that values have increased on all of the material entering into the construction of water-works plants in the last few years, and this fact has caused the value of the Bienville company's plant to be placed somewhat higher than would otherwise have been the case. But it may be pointed out that there is no apparent possibility in the near future that these values will seriously decrease, and it should also be remembered that these increased values apply equally well to the property of the city of Mobile as to that of the Bienville company.

Supplementary Letter No. 2.—By Mr. John W. Hill.

COMPARISON BETWEEN MOBILE AND DENVER.

The city of Denver, Colo., is as near a parallel to Mobile in this respect as any city well can be. There for several years two works were in active competition, the Denver City Water Co. (a consolidation of the Denver Brook and Mountain Water companies, 1890), and, 1891, the Citizens Water Co. For several years these two companies were in competition, the Citizens Co. for a time supplying water at no charge, with a view to ruining the Denver Water Co. Neither company paid even operating expenses, and the situation become so grave that the bondholders of both companies agreed upon a union of interests, resulting in the formation of the Denver Union Water Co., 1894, and the establishment of a set of water rates which would pay operating and maintenance charges, and offer some relief to the bondholders.

About 70 miles of principal mains were paralleled and for several years, as stated, the consumers in some parts of the city received their water ad libitum and gratis. In 1898 the revenue was about $650,000 for a population of 150,000, with operating and maintenance charges (on what are principally gravity works) of less than $200,000, leaving about 4½% to pay interest on a bond and stock capitalization of $10,000,000.

The Citizens Water Co.'s works bore about the same relation to the Denver Water Co.'s works as the city of Mobile's water-works bear to the Bienville Co.'s works, both in age of service and the paralleling of all important lines of distribution pipes. The warfare for about three years promised to result in the financial ruin of both companies, and wise heads like Mr. D. H. Moffatt, of Denver, and Mr. E. H. Rollins, of Boston, saw that the only solution for the two companies and protection of the bondholders in each, lay in the consolidation of the rival interests. To-day the Denver Union Water Co. is one of the most valuable water properties in the United States. Some details of this affair are given in the "Manual of American Water-Works," 1897 (p. 531).

An attempt was made by the city during the term of Mayor McMurray to invade the city contract made with the Denver City Water Co., 1891, but this move in the courts failed because it was held by Judge Le Fever, that the contract was a mutual agreement, and could not be traversed on the motion of one party. The Citizens Water Co. was a local organization intended to overcome the supposed oppression of the Denver City Water Co. in the matter of water rates, which brought about a condition which for several years at least threatened the interests of the city. About 1898 or 1899 the city procured legislation to enable it to build a third general system of water-works, but I believe no contracts were ever made and the Denver Union Co. is the only corporation in the water supply business in that city at this time.

The conditions at Denver (1894) were worse than those now existing at Mobile, and the gross cost of water-works per capita was $70 (or $10,000,000 for 150,000 population), as against $35 at Mobile ($1,450,000 for 40,000 population), or about one-half. It was, therefore, a much more difficult problem to solve, especially as the consolidated Denver Union Water Co. had to depend upon a city contract for a term of years, for its life. In due time the city may take over the water company's property. Action looking to this was started in the spring of 1898, but afterwards abandoned, while plans were being made for city works, which (so far as I am aware) never reached the condition of construction contracts.

I was employed by the city in 1898 to investigate and testify in court upon certain features of the controversy between the city and the company, and felt at that time that the city should if possible acquire the property of the company, and place the supply of water wholly under municipal management, even though it involved a price for the property which to some of the city officials seemed too high.

Supplementary Letter No. 3.—By Mr. M. F. Sullivan.

REVIEW OF THE CONDITIONS.

The extract quoted in our report from the decision of the Supreme Court implies that a municipality has no legal right to appropriate or destroy the tangible property of a corporation. The question naturally arises whether the city has sought to accomplish this, either directly or indirectly. The municipality operates a public enterprise under legislative authority, in competition with a private one of the same character, and organized and chartered by the same legislative body. By reason of such competition, the private corporation has been unable to meet the fixed charges and operating expenses from the reduced revenue, and is compelled to continue operations until the expiration of the franchise period to protect its chartered rights. During this time its property has evidently depreciated as an investment, and the securities issued to establish a going business are in the hands of innocent purchasers, with no future prospects of realizing any returns on their holdings, and possibly subject to future demands for additional funds with which to carry on the business. Have these parties any grounds for relief? If so, upon whom?

Individually I cannot understand how the city of Mobile as a municipality can in any manner be responsible for the depreciated values of the Bienville Water Supply Co.'s property, unless it can be proved that no organized legal effort had been made on the part of the city to purchase this property at its fair valuation, before the construction of the municipal plant was undertaken. It cannot be denied that the private corporation has some rights to protection, as it invested its capital in providing a public necessity to the citizens and city, when, perhaps, the financial condition of the city's resources would not permit of its undertaking the work. So long as those rights have not been exceeded or violated on the part of the company, some consideration should be shown. These and many similar questions were discussed by the board, and it was decided to leave the settlement of all legal points raised, to the two interested parties, with a hope that a satisfactory settlement would be made.

It was evident from the financial showing made by the company that under existing conditions very little value could be placed on the property, from the standpoint of revenue that could be derived from it. The rules for the determination of values for property of this kind have not only been passed upon by boards of appraisers and arbitrators, but also by the courts, upon either of the following basis: 1, Cost of construction; 2, capitalization of net revenues; 3, cost of reproduction. In following the findings of such boards in the majority of cases, and the ruling of the courts, the last method has proved the most satisfactory, so far as the tangible physical property is concerned, and the board felt that it would be bound by previous judicial actions and findings, to proceed with the valuations on the basis of reproduction, at the present prevailing prices of machinery, materials and appurtenances, less deterioration.

It is extremely unfortunate for the city and company to enter into this enforced competition, resulting in the demoralization of rates on both sides; which, in the city's case, affects the proper control of the enormous waste of water, rather than the cutting of rates, as the adopted schedule rates have been fairly maintained. But this needless waste of water is bringing about a condition of affairs in respect to the city's plant, which renders imperative the adoption of proper measures to prevent its further continuance, or we will be compelled to seek additional water supply. For several days during the past summer all of the available water in the creek was being pumped into the reservoir and city, and this quantity was barely sufficient to meet the demands, leaving nothing to augment our storage supply in the reservoirs. Should a continued drought prevail, we would not secure sufficient water to satisfy the demands. We can ill afford these conditions to continue, as it would be placing in jeopardy all of the property within the city, in case of a conflagration, and require the fire department in all instances to resort to steamers for obtaining fire streams. This excessive waste not only brings about the reduction of pressure on the street mains, but increases the cost of maintenance.

We are now consuming and wasting nearly 9,000,000 gallons of water daily; this quantity is more than double ordinary legitimate use, and involves an extra expenditure of about $250 per month for fuel alone, besides the extra wear and tear on the machinery, thereby shortening the actual life of the plant, without considering its inadequacy in a short time, to supply the increasing demands, which will render necessary the purchase of additional machinery with increased capacity. As the present machinery is sufficient for the quantity of water available from our present supply, a new supply would have to be secured, additional force mains provided, larger reservoirs constructed, and possibly a filter plant installed. This would involve a large expenditure, and perhaps the abandonment of the present plant.

These same conditions with respect to waste prevail with the Bienville Water Supply Co. also, but to a greater extent than with our own plant, as its per capita consumption exceeds ours by over 60 gallons; in fact, it appears as though it had encouraged waste by the removal of all meters from the service. Hundreds of other cities have struggled with this water waste problem, without accomplishing satisfactory results until meters were introduced, and their experience seem to point to this as the only remedy.

To adopt the universal meterage of water furnished to the city's customers at the present time, would undoubtedly deprive us of some patronage, owing to the general disfavor which is known to exist against their use. To what extent this would affect our present income is a matter of conjecture. However, we do know that our per capita consumption would be reduced at least 50%, and our operating expenses would also be reduced in proportion to the saving made in fuel, and we would have a resultant increase in our water supply, equal to the waste prevented thereby. But while we are doing this, our competitor will have increased its revenues in proportion to the number of customers taken from us, and will very likely continue to secure others who may become dissatisfied with a particular meter bill, and the labor and expense of installing the meter in such cases will be lost.

Thus, in the application of any remedy proposed, we are confronted with the conditions of competition which encourages lavishness in the use of water, incurs extraordinary expense for maintenance, and an unstable patronage. For these reasons, in my judgment, the only practical solution of the situation is to purchase the property of the Bienville Water Supply Co. upon the best terms that can be secured.

The city will no doubt consider the valuation placed on the property by the appraisers as high, and viewing it from the standpoint of an investor, where the business is to continue under present conditions, it is high. But the property has a nuisance or annoying value which we can not fail to recognize and which must be regarded as a particular asset. It is true the company would have great difficulty in disposing of its plant at anything near its cost value to a private investor, to be operated in competition with the plant owned by the city. On the other hand, the city would encounter the same difficulty in disposing of its plant to parties other than the Bienville Water Supply Co., if both plants were to continue as at present. Therefore each plant is depreciated by the existence of the other, and real values only depend on earning power.

The prices fixed on the tangible property of the company by the appraisers is based upon present current prices, which are nearly 100% above the prices of materials at the time the city's plant was built. As a matter of information, I have applied the prices paid by the city for the various similar items corresponding to the valuation found, and had an appraisement been made of the property at that time, on the same basis now used for the tangible property, it would have amounted to $376,412. But at that time the company's plant had a going value, which is ascribed to an assured business enterprise that has a developed earning power, and its value is usually determined by the sum of the yearly revenues, reduced to their present worth.

That portion of the Bienville company's plant which could be directly utilized by the city, consisting of water supply, pumping station, machinery, reservoir, and 24-in. supply main into the city, would cost $406,500 to duplicate at the present time under prevailing prices. In other words, the total valuation found by the appraisers, for the tangible property of the company, exceeds by about $200,000 the legitimate expenditure by the city to provide what is most needed to relieve the present situation of shortage in water supply and storage, together with a duplicate force main into the city.

This amount represents the present market value of that portion of the company's system which the city could not directly utilize at the present time, but this material could be taken up and stored, to be used in future extensions later on, or sold. In this way we would be probably able to realize about 40% of the amount paid, after deducting the cost of placing it on the market. This would then leave an expenditure of about $120,000 which we would lose in physical values by purchasing the property at the valuation found by the appraisers. The interest and sinking-fund charges on this amount, at 4½%, and 2 1-10% for sinking fund, would amount to an annual years, and at the same time accomplish the removal of competition

NOTES FROM THE ENGINEERING SCHOOLS.

WESTERN UNIVERSITY OF PENNSYLVANIA.—It is reported that Andrew Carnegie, Charles M. Schwab and others have offered to raise funds to so equip the university that it may finish the technical education of graduates from the Carnegie Technical School.

LEHIGH UNIVERSITY.—Alexander Macfarlane, M. A., D. Sc., LL.D., of Chatham, Ontario, the well-known mathematician and physicist, is delivering, before the students of Lehigh University, a series of six lectures on "British Mathematicians of the Nineteenth Century." In this

course Dr. Macfarlane discusses the lives and work of T. P. Kirkman, Charles Babbage, William Whewell, C. L. Dodgson, G. G. Stokes, and Lord Rayleigh. These lectures supplement a similar course on the same subject delivered last year in which James Clark-Maxwell, Henry J. S. Smith, William J. M. Rankin, James J. Sylvester, Peter G. Tait, and William Thompson, first Lord Kelvin, were discussed.

UNIVERSITY OF MICHIGAN.—Thirty of the engineering students of the University have signified their intention of participating in the annual spring trip to several of the important manufacturing centers of the country. The trip will require ten days, April 11 to April 21. The cities that will be visited are: Toledo, Pittsburgh, Philadelphia, New York and Niagara Falls.

UNIVERSITY OF MISSOURI.—The class in Geology and Mining, of the Missouri School of Mines and Metallurgy, will make a summer excursion this year, in charge of Director Ladd, to the Black Hills, Butte and Anaconda and the Yellow Stone Park. Similar excursions will in the future be a required part of the work at this institution.

The new catalogue of this school announces that during the spring and summer months, as a part of regular courses, excursions will be made to the Joplin mining district for mine surveying; to the Gasconade River for field practice in lines of communication; to southeast Missouri for geological field work; and to Joplin, St. Louis, Herculaneum and the Flat River district for the study of mine, ore dressing and metallurgical plants.

CHANGES IN CONSTRUCTION OF BARRIER No. 1 on the Yuba River, California, are contemplated, it is said. The Atlantic, Gulf & Pacific Co. was awarded the contract ($28,000) for building this barrier to impound the debris from hydraulic mining, but the company has found it impossible to drive the plank sheet piling in the bed of the river owing to the great number and size of cobblestones. This "barrier" was described in Engineering News, Jan. 15, 1903.

ENGINEERING WORK ON THE LOUISIANA PURCHASE EXPOSITION AT ST. LOUIS.

Presumably all of our readers know that a great international exposition is in preparation at St. Louis, Mo., to celebrate the centenary of the "Louisiana Purchase," by which, in 1803, the United States government acquired from France all the great territory owned by the latter west of the Mississippi River. Presumably, also, all of our readers know that delays in the prosecution of the negotiations and the work led to the postponement of the exposition from 1903 to 1904. Probably few of our readers, however, realize the scope of the exposition and the progress which has been made on the construction work. As much of this work is of a distinctively engineering character, we have recently taken pains to investigate it somewhat thoroughly, and the following article has been prepared from information obtained during a recent visit of inspection to the works by a member of our editorial staff. We are indebted to many of the officers mentioned below for courtesies shown and for plans and information furnished.

Before taking up the technical details of the work it will be of interest to briefly describe the general situation. The site of the exposition is the western half of Forest Park, the use of which has been granted by the city; and this is supplemented by about 400 acres west of the park, which property has been leased by the exposition company. The total area enclosed will be nearly 1,200 acres, or almost exactly double that of the Columbian Exhibition at Chicago in 1893.

The leased land includes the new property of Washington University, upon which large and handsome permanent buildings have already been built, and these buildings will be used for the purposes of the exposition. The main building is now occupied as the Administration Building, with the Division of Works and Department of Civil Engineering in the two wings. The library building will be utilized for the accommodation of the various congresses which are to be held at or in connection with the exposition. At the close of the exposition the property and buildings will be turned over to the university, and the park will be restored to its former condition. Fig. 1 is a general plan of the exposition ground, with contour lines indicating the character of the topography of the site.

For the purposes of administration a company has been organized, under the name of the Louisiana Purchase Exposition Co. Mr. David R. Francis, ex-Governor of Missouri, is president, and Mr. Walter B. Stevens is secretary. There are 8 vice-presidents and 93 directors, while the executive affairs are in the hands of 15 committees. The committee system, however, has been found here (as at Chicago) a source of trouble and delay. The members are business men whose interest in the exposition must necessarily be subordinated to their business affairs, and it is therefore difficult to get them together at the particular times when their

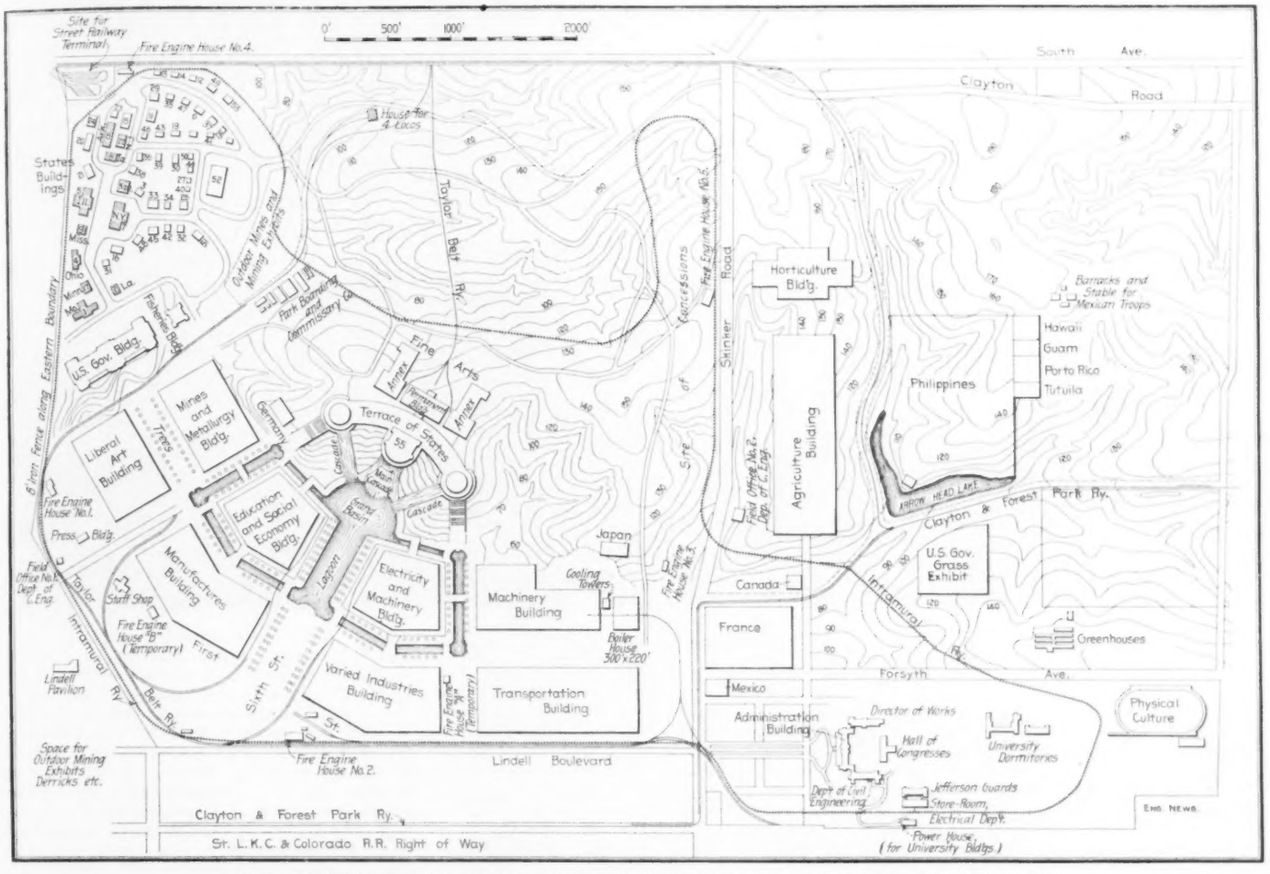

FIG. 1. GENERAL PLAN OF THE LOUISIANA PURCHASE EXPOSITION, ST. LOUIS, MO., 1904.
(Only those State Buildings Shown by Hatched Lines are as yet finally located.)

Index to State Buildings.

1	Missouri	28	Idaho
2	Louisiana	29	North Dakota
3	Texas	30	Arizona
4	Ohio	31	Nebraska
5	Illinois	32	Wyoming
6	S. Carolina	33	Washington
7	New York	34	Oregon
8	Arkansas	35	South Dakota
9	Mississipp.	36	Virginia
10	Kansas	37	Alabama
11	Pennsylvania	38	Tennessee
12	Georgia	39	Connecticut
13	Utah	40	Indiana
14	Montana	41	Michigan
15	Colorado	42	Massachusetts
16	Wisconsin	43	New Hampshire
17	Minnesota	44	Rhode Island
18	Iowa	45	Vermont
19	Kentucky	46	Delaware
20	California	47	North Carolina
21	New Mexico	48	Oklahoma
22	New Jersey	49	Alaska
23	Maryland	50	Ind. Ter.
24	Florida	51	Hoo Hoo
25	W. Virginia	52	Frat. Bldg.
26	Nevada	53	Burns' Cot.
27	Maine	54	T. P. A. Bldg.
		55	Festival Hall.

action is desired. There are so many matters of large importance and of detail, and so many interests involved, that it requires skillful organization to keep things going on the various parts of the work and to avoid interference between them. Great delay results from the fact that under the existing system of management every step has to be submitted to one or other of the committees for approval, and this approval must await the convenience of the members of the committees. At the present time, however, much work is started before the formality of its approval by the committees, which facilitates progress but is not good practice on general principles.

Even when working with the greatest harmony the committee system involves many cases of interference and difference of opinion, which have to be settled by discussion or negotiation. With every desire for harmony, the construction work has undoubtedly been seriously hindered, and it would have been practically impossible to have had the construction work and decorative work fully completed and exhibits installed by April 30, 1903. The postponement to 1904, however, appears to have been looked upon as giving ample time for the work, and little appears to have been gained towards pushing the work more vigorously. While the work is progressing fairly well, yet from present appearances and conditions it seems probable that unless the management promptly undertakes a general acceleration all along the line there will be a great and inconvenient rush to finish things up a year hence. Some steps have already been taken to simplify the present decentralized system of management, but it is not surprising that it is now proposed to make the director of works the executive head of all construction work. This system of organization was successfully employed at Chicago to facilitate and expedite progress under very similar conditions. The function of the committee would then become advisory instead of executive, and the work would progress more rapidly and systematically and therefore more efficiently.

It must be remembered that the great buildings, while most conspicuous, do not represent the largest part of the construction work. This work is of a most varied character. It includes the grading, water supply for domestic service and fire protection, roads and railways, sewerage and drainage, foundation works, electrical conduits and distribution systems, and innumerable minor structures and construction details, many of which come up unexpectedly and cannot be planned for in advance. All the various items of work must be prosecuted simultaneously and with as little interference with each other as possible. The final work of finishing up matters of detail, cleaning up the grounds, dressing the slopes and lawns, repairing roads, and putting things in shape for the public opening is also a matter of no small importance.

CIVIL ENGINEERING DEPARTMENT.

This department undertakes all survey work and estimates for construction, outside of the strictly architectural or building work, and has charge of the grading, roads, water supply for domestic service and fire protection, sewerage and drainage, and intramural railway facilities.

This department occupies the Cupples wing of the Administration Building. Its organization comprises a chief engineer, assistant engineer in charge of different divisions of the work, 15 draftsmen, and 35 outdoor men engaged on surveys and inspection work. The principal members of the engineering staff are as follows: Richard H. Phillips, Chief Engineer; H. R. Fardwell, Principal Assistant Engineer; C. E. Young, Engineer of Water Supply, Sewerage and Fire Protection, with W. R. De Witt as his chief assistant; E. R. Kinsey, Engineer of Lagoons, Roadways and Gradings, with F. H. Hilliard as his chief assistant; E. C. Finley, Engineer of Railways, with G. M Derickson as his chief assistant; E. D. Williams is Chief Engineering Draftsman, and he also attends to the records of progress and to some of the outdoor work.

An interesting detail of the work of this department is the preparation of monthly progress maps on a scale of 100 ft. to the inch. The plan is a contour map made in pencil on tracing cloth, and each month the work done in the way of roads, pipes, sewers, railways, buildings, etc., is inked in and indicated by hatched lines, etc., as required to make it conspicuous. Blue prints of this large plan are then furnished to the various departments. In addition to the permanent work, the map shows camps and temporary buildings, piles of logs or timber, heaps of black dirt saved for dressing, etc. This is done to show just exactly what is on the ground, so that if any excavation or construction is to be undertaken at a certain point, the map will show what obstructions exist, and whether these are in the way of temporary or permanent work. Similar but smaller progress contour maps are made on a scale of 300 ft. to the inch for more general purposes.

GRADING.

The exposition grounds are not level, the general elevation being 60 ft. above St. Louis city datum, while the maximum is about 120 ft. above datum. This datum is mean water level in the Mississippi River, which is 473.71 ft. above mean tide at Biloxi, Miss. A level space at the normal level of the park forms the site for the main group of buildings, but directly beyond this there is a steep slope rising to an elevation of about 65 ft., and beyond this is wooded rolling country. Under these conditions a very large amount of grading is required to form sites for buildings and to produce the desired landscape effects. In fact, more or less grading is required in connection with almost every piece of work undertaken, and has proved quite a serious proposition. It ranges from light leveling and filling to 25-ft. cuts, extensive areas of grading for building sites, cutting off hill tops and filling in ravines. The shape of the south side of the Machinery Building is due to the fact that to have made the building rectangular would have involved a very heavy cut in the hillside. The ground is mainly a stiff clay with some brown shale. This clay is very hard to excavate when wet and when frozen. The clay and shale are used in making the molds for the staff decorative work and statuary, being worked up in a pug mill.

The grading will aggregate about 2,000,000 cu. yds., of which 1,500,000 cu. yds. were completed or under contract in December. This is exclusive of foundation work and of the trenches for sewers, water pipes, electric conduits, etc. For the heavy work with long haul, grading machines of the Western and New Era style have been employed, each machine being handled by 16 horses or mules, or by a traction engine. In wet weather and soil the engine wheels slip, and under such conditions better progress can be made with teams. At one time about 12 graders with traction engines and 6 with horses and mules were at work. The engines were of 22 and 27 HP., the latter being preferred. Fig. 2 shows grading machines hauled by engines and teams, and also the dump carts. Besides these, two steam shovels have been steadily at work in shale excavation and heavy cuts, and one of these is shown in Fig. 3. Numerous small pieces of light work with short haul have been done by wheel and drag scrapers and the aggregate amount of this work is very considerable. All black dirt is saved and piled for use as top dressing of finished slopes and surfaces.

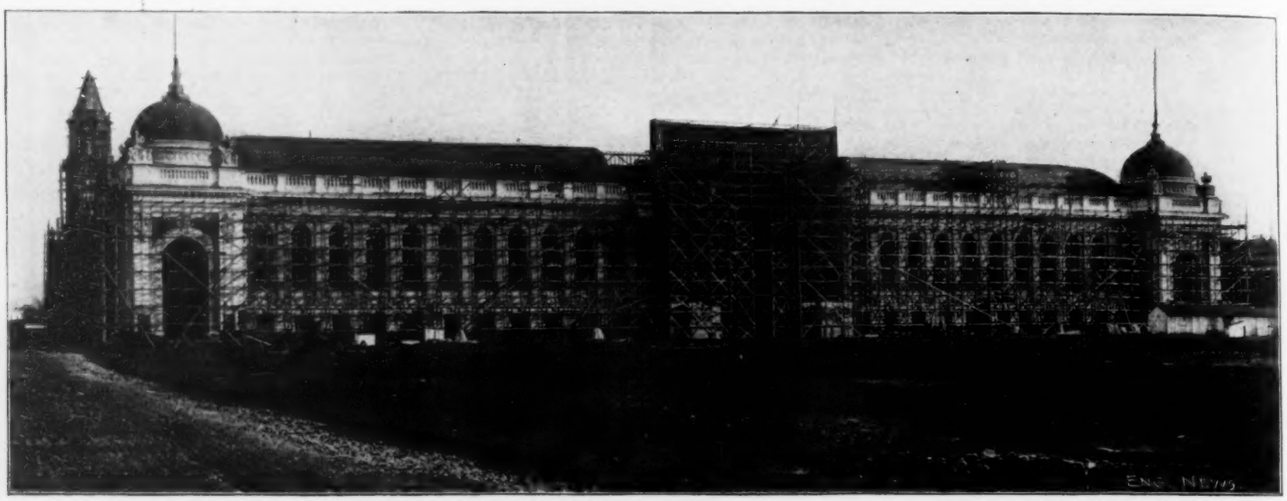

FIG. 2. VIEW OF WEST END OF VARIED INDUSTRIES BUILDING.

About 500,000 cu. yds. of grading on the heaviest part of the work have been by the Southern Paving & Construction Co. and Maloney & Morrison, working together. This work comprises the following: Skinker Hill, 251,000 cu. yds.; Agriculture and Horticulture buildings, 175,000 yds.; Liberal Arts Building, 40,000 yds.; Mining and Metallurgy Building, and enlarging Arrowhead Lake, 9,000 yds.; Tesson tract, 40,000 cu. yds.

The importance of this grading work may be gathered from an inspection of the general contour map, Fig. 1. The elevation of the ground around the main building facing the lagoon is about 60 ft. above datum (mean water in the Mississippi), the site of the U. S. Government Building has been graded to an elevation of 95 ft., and that of the Agriculture Building to 122 ft., while the Fine Arts Building is 125 ft. and the Administration Building about 120 ft. above datum. The walks leading up to the curved colonnade on the brow of the hill begins at 65 ft. and rise to 115 ft. at the beginning of the flights of steps, while the elevation of the colonnade itself is about 124 ft.

DRAINAGE.

The drainage area of the exposition site is about 1,200 acres, but the River Des Peres, which passes through the grounds, has a drainage area of 14,000 acres, and this had to be provided for. The river is normally a very small stream, and originally had a very tortuous course, which it was necessary to change in order to accommodate the building plan. Its original length of 8,800 ft. through the grounds has been reduced to 4,650 ft. The new channel is 50 ft. wide and 15 ft. deep, built of timber and lined with plank. It is roofed over and forms a roadway, which is to be paved with asphalt by the Barber Asphalt Co. Longitudinal partitions divide it into three parallel channels. At the lower end are flap doors, hinged at the top, which prevent people from entering. Similar doors are placed at intervals of 500 ft. along the channels, as in case of a fire an open channel might act as a great flue. Beyond the exposition grounds the course of the stream has been straightened and cleared to prevent water from backing up in time of flood.

From this drainage channel for the Des Peres River run wooden box drains as required to carry off storm water from the ravines, etc. These are 12 × 12, 8 × 8, 8 × 12, and 6 × 7 ins. Under the roadways are drains of 8 to 18-in. vitrified pipe, with wooden-grated inlets 18 × 18 ins. in the gutters. The main waterways are calculated for a rainfall of 3 ins. per hour; while the smaller drains (24-in. and under) are calculated for 1 to 2 ins. per hour. The drains or storm water sewers will aggregate about 13 miles, of which six miles (including only smaller diameters) are yet to be built.

SEWERS.

The sewerage system will aggregate about 10 miles of brick and pipe sewers, of which about 5 miles (mostly 6, 8, 10 and 12-in.) remain to be built. The 15, 21, 27 and 48-in. sewers aggregate 6,700 ft.; they are built to the city's specifications and will be permanent, forming part of the city sewerage system after the close of the exposition. There will be 1,200 ft. of 15-in., 1,500 ft. of 21-in. 1,000 ft. of 27-in., and 3,000 ft. of the 48-in. main brick sewer which leads to the sewage collecting wells. This latter sewer will eventually be extended and form one of the city's storm-water sewers. The wells are two in number, 15-ft. diameter and 15 ft. deep, and from them the sewage is raised 25 ft. and discharged into a 24-in. cast-iron outfall sewer, leading to one of the city's main sewers. Each well has two electric centrifugal pumps of 240,000 gallons capacity per hour. There will thus be a pumping capacity of nearly 1,000,000 gallons an hour, but it is not likely that more than two pumps will be required at the same time. Inside the building there will be about 8 miles of 4-in. and 6-in. sewers (for waste water only, not closet connections), laid together with the inside water pipe system. The main sewers are laid in trenches in the usual way, but are supported on timber trestling through soft ground. Fig. 4 shows an Austin trenching machine (Eng. News, Sept. 19, 1901), being hauled by a gasoline traction engine.

WATER SUPPLY.

The domestic water supply is taken from a 36-in. city main which parallels the east boundary of the site, and 12-in. mains on the north and west sides of the park. The distribution system comprises 10 miles (of which 6 are already laid) of 6-in. to 12-in. pipe outside the building, and 8 miles of ¾-in. to 3-in. pipe inside, the latter being laid in the same trenches with the waste water sewer pipes. The mains through the grounds are laid in trenches, but if the ground is soft they are laid on plank supports or trestles. The water will be distributed at the city pressure of 95 lbs. direct from the main, without the aid of pumps at the exposition. Hydrants are set at intervals of 150 ft. inside and outside the buildings, the outside hydrants being about 100 ft. from the buildings. City water will also be used for the grand basin, cascades, fountains, lagoons, etc., and in order to improve its appearance it will be filtered to remove the matter held in suspension.

FIRE PROTECTION.

As all the buildings, except the Fine Arts Building and boiler house, are of wooden frame construction, special attention has been given to the question of fire protection. The water supply for this purpose will be taken from Arrowhead Lake, the natural lake at the west side of the grounds, which has a storage capacity of 7,000,000 gallons. This lake is fed by surface drainage, and is also connected by pipes to the city water supply. From this lake, a 24-in. water main will deliver the water to the power house, 2,200 ft. distant, in which will be installed 14 standard Worthington underwriter fire pumps, each with a capacity of 1,000 gallons per minute. In addition to this lake, the suction pipe will be connected to the city main by two 12-in. pipes.

The fire mains outside of the buildings comprise about 15 miles of 8-in. to 20-in. wrought-iron pipe. The hydrants are set at intervals of 150 ft. outside of buildings and about 100 ft. from the building line. Each outside hydrant has two 2½-in. nozzles, with independent shut-off valves; also one 4-in. steamer nozzle. Inside of the buildings there will be 14 miles of 2-in. to 6-in. wrought-iron pipe, with 4-in. hydrants at intervals of 150 ft. on the main floor. The hydrants are placed close to interior columns, or between the columns along the curtain walls of the courts. There will also be about six miles of ¾-in. to 4-in. pipe for the automatic sprinkler system, which will have steamer connections at convenient points outside.

Connected to the fire protection mains will be 50 deck turret 3-in. nozzles, similar to those on fire-boats, placed on platforms about 35 ft. above the floors. Each main building will have four or more of these. These deck turrets will be capable of being revolved by gearing through horizontal and vertical angles, and will throw streams a distance of 350 ft.

There will be but few galleries, and these will be served by vertical pipes, having lengths of hose attached. Vertical risers will be carried to the roofs and connected across with lines of 4-in. pipe, on which there are 1½-in. hose connections, 100 ft. apart. The fire protection system is designed for a working pressure of 150 lbs. and to be tested to 300 lbs. per sq. in.

The contract for the fire protection pipe on the main buildings was awarded to the Hanley-Casey Co., of Chicago, at $283,000. On this line there will be 325 fire hydrants outside of buildings and 250 hydrants inside of buildings, with 545 gate valves.

There are four fire engine stations, manned and equipped by the exposition company, but many of the men have been city firemen, and the chief was an assistant-chief of the St. Louis fire department. The four fire companies have about 65 men in all. Each station has a steam fire engine of the Ahrens type, a chemical engine, and hose wagons, while one has a ladder truck in addition. Two additional engine houses will be built. About 75,000 ft. of hose will be required, and 10,000 ft. have already been purchased.

ELECTRICAL CONDUITS.

The main electrical supply cables are led through a subway or conduit 7 × 8 ft. This is about a mile in length, and is supplemented by wooden pump log conduits leading to all parts of the buildings and grounds. These conduits give a total length of about 100 miles of duct. The large conduit starts from the base of the tower in the Machinery Building, which supports the main switchboard.

WATERWAYS.

The total length of waterway through the grand basin and the canals which separate the main buildings will be about one mile. The length across the chord of the basin is 600 ft., and the distance from the foot of the main cascade to the end of the lagoon is 1,150 ft. The width of the lagoon is 250 ft., and that of the canals is 75 ft. The latter will be crossed by 12 bridges, two of which will be 80 ft. wide, and the others 50 ft. wide. These bridges will be timber structures, covered with "staff" decorative work. The lagoons provide a water trip of 7,000 ft. in length by the shortest course; they have an area of about 17 acres and contain about 19,000,000 gallons of water.

The lagoons, canals and basin, have a plank revetment spiked to waling pieces between piles driven to a depth of 6 or 8 ft. On the water side there is a sheathing of flooring planks 4 ins. wide, laid horizontally and with open joints which will be closed by the swelling of the wood when water is admitted. On the bank side of the piling is a sheathing of 8-in. vertical rough oak planks, behind which the earth filling is well rammed. The depth of water will be about 3½ to 4 ft. at the sides, and 4½ to 5 ft. at the middle. The basin will have the bottom covered with planking, to prevent the currents from the cascade from stirring up mud. It has not yet been decided whether or not to cover the bottom of the lagoon, but this will probably be done, as otherwise the screws of the electric launches would probably stir up the mud.

FIG. 3. TRACTION ENGINE HAULING GRADING MACHINE.
M. Rumely Co., Laporte, Ind., Builders of Engine.

ROADWAYS.

There will be about 35 miles of driveways and roads, 50 to 75 ft. wide. These will be mainly of macadam construction, but the telford system will be used in soft ground and where heavy teaming must be provided for. In all cases there will be a gravel top dressing, so as to avoid the glaring appearance of white stone roads in the sun. About seven miles of macadamized road 20 ft. wide have already been built for construction purposes. The walks will be partly of concrete and partly of asphalt, a contract for asphalt paving on the walks having been awarded to the Barber Asphalt Co. on March 28. Fine burned clay is also being tried as an experiment; loose gravel is unpleasant to walk upon, and the burnt clay seems to pack more closely. This same material may also be used for the roadways and its dull red color would harmonize with the green lawns and "ivory white" buildings. About 50,000 cu.yds. of this material

have been purchased. In all there will be about 500,000 sq. yds. of roadways and walks. Along the roadways through the main group of buildings are rows of maple trees, 8 to 14 ins. diameter, which were transplanted by the Landscape Department. These trees are 75 ft. apart, and 82 ft. 6 ins. from the buildings.

RAILWAYS.

An extensive railway system is required for the distribution of construction materials and exhibits. Part of this will remain during the exhibition, while other parts will be temporary spurs put down as required. Some comparatively heavy work is required in getting access from the general level of the park to the elevated portion of the grounds. There will be about 25 miles of railway, of which 9 miles had been built in December. The construction and the track conform to general railway practice. Ravines are crossed by timber trestles aggregating 3,000 ft. in length, and having a maximum height of 40 ft. The maximum grade is 2.5%, and the sharpest curves are of 20°, although a few 22° to 25° curves will have to be put in later for the installation tracks. The rails weigh 60 lbs. per yd. The line is known as the Taylor Belt Ry. Two engines are now in use for hauling railway material and building material. Two more will be put in service shortly. Yard tracks have been established on the south side, and a house is being built for the engines and coal storage.

INTRAMURAL TRANSPORTATION.

It is intended to provide a better and more convenient system of intramural transportation than has been provided at any previous exhibition of this kind. Various plans have been suggested, including electric surface and elevated railways of different types, automobiles and motor cars or omnibuses, etc. The electric launches on the lagoons will be used for pleasure trips rather than as a means of transportation from place to place.

One suggestion which is now being considered provides for a complete system of automobile cars, including two distinct services; the first of these would have long runs and serve the main routes; the other would connect with these and run direct to the buildings and other special points of interest. This would give close connection between any given points, and would avoid steps or stairways. It seems hardly possible that such a system could be seriously considered as the principal means of transportation for large numbers of people along crowded avenues and over such an expanse of territory as that covered by the exhibition grounds. The speed of the cars would necessarily be low, especially in the main part of the grounds where crowds would concentrate, and a journey around or across the grounds would occupy considerable time. Under such conditions a very large number of cars or omnibuses would be required, increasing the danger of running over people. To allow of increased speed, a special system of roadways with overhead crossings of the main thoroughfares has been proposed. This, however, would require a great amount of grading and construction work and rearrangement of the grounds. There is no doubt that there will be an ample field for an automobile service auxiliary to or independent of the main system of intramural transportation, but such a service does not appear to fulfill the requirements of the main system.

An electric railway system appears to offer the best solution of the problem of rapid and convenient transportation, and plans have been made for such a system, forming a belt line and also two loops so as to serve not only the main buildings, but also the concessions, the State and foreign buildings, etc., and to serve the greatest possible area without serious interference with the artistic or architectural features of the exposition. It will be a surface line (on a fenced right of way) on the higher ground among the State buildings, the Midway and other incidental attractions. On the lower ground, where the main buildings are situated, it will be carried on a timber elevated structure, built probably of 12-ft. towers and 30-ft. Howe truss deck spans. The line will run behind the main buildings, and as the structure would not harmonize well in a view of these buildings it will probably be concealed by some form of architectural screen, so as to be invisible to observers on the hill, from which there will be excellent views of the central portion of the exposition lying below. It will be operated by the third-rail system, and standard types of motors, trucks, and electrical apparatus will be used, so as to be available for street or elevated railway use after the close of the exposition. There will be about six miles of single track. The plans are practically complete, but the work has not yet been advertised. The surveys for location and profiles of these lines were made under the direction of Mr. Richard H. Phillips, Chief Engineer, and the development of the details of the construction of the elevated portion and the entire equipment and operation of the intramural railway has been put into the hands of Mr. Charles V. Weston, M. Am. Soc. C. E., Consulting Engineer, of Chicago. The general scheme and the detail plans have been in the hands of the Executive Committee for some weeks, but certain objections have been made on account of the cost, interference with entrances and architectural features, etc. The architectural features, however, are merely an incidental part of the exposition, and it is to be hoped that the provision of an efficient system of intramural transportation will not be subordinated to such matters.

THE CASCADES.

These will form the principal spectacular feature of the exposition. As already noted, the cascades and intermediate slopes will be fitted to the face of a natural hill or bluff, some 65 ft. high, crescent-shaped in plan. But the curve of the work does not conform to the natural curve or slope, so that considerable grading has been required (about 270,000 cu. yds.). At one side this work is in excavation; but on the other side it is supported by timber trestling, the height above the natural surface being too great for filling, owing to the settlement, as it was essential that work should be started at once.

The steps and terraces are of 2-in. concrete, with expanded metal embedded within it, and finished with a granitoid surface. On the risers of the steps, however, the thickness is only 1 in. The waterway or channel of each cascade is divided into three parallel channels by narrow copings decorated with statuary. The waterways have a sheeting of 2-in. plank, covered with 1-in. matched flooring, upon which is tacked a lining of cotton duck. The lining is heavily coated with white lead at the joints and given three coats of paint. The face of the hill, between the cascades, will be graded to a concave slope and covered with turf, the width across the slope being about 1,600 ft.

The flow of the three cascades and their auxiliary fountains, etc., will aggregate about 90,000 gallons per minute, that of the main or central cascade being 57,000 gallons, and that of each of the side cascades 18,000 gallons per minute. The flow of the cascade at the Buffalo Exhibition in 1901 was 11,000 gallons per minute. According to a description of this, prepared by Mr. Isaac S. Taylor, Director of Works, the main cascade will issue from a 30-in. pipe and have 13 falls; the first fall is 21 ft.; the third, 17 ft.; the second and fourth, 8 ft.; and all the others 3½ to 4 ft. each, the total fall being 89.75 ft. The width of the first fall is 40 ft. with water 11 ins. deep; at the last fall the width is 140 ft. and the depth of water 3 ins. Behind the 20-ft. fall will be a grotto, open to visitors. The two side cascades flow each from a 12-in. pipe and have 15 separate falls, aggregating 80.30 ft. The first fall is 4½ ft., the last 6 ft.; there are two of 13 ft., and the others are of 3 ft. each. At the sides of the cascades will be numerous fountains and vertical and horizontal jets of water, while at the bottom will be four 3-in. jets rising to a height of 75 ft. in calm weather.

The water for the cascades will be drawn from the lagoon and canal system and used over and over again. Provision is being made to properly filter the water on its initial introduction and the bottoms and sides of the canals will be sheathed so that practically no foreign matter will be in suspension. In order to provide a circulation for the canal system, the 90-in. suction intake is carried down about 1,500 ft. from the pump-house.

The water will be pumped by a special pumping plant installed beneath one of the side cascades, and this plant will have a capacity sufficient to elevate 90,000 gallons per minute to a height of approximately 102 ft. These pumps will be of the centrifugal type, operated by induction motors of approximately 2,000 HP. capacity. In order to allow the motors to accommodate themselves to the speeds of the pumps these motors will be of special design and be suitable for operating on a 25-cycle three-phase current. This will probably be the largest pumping outfit ever used for such a purpose. The firm of Henry R. Worthington will furnish these pumps, as well as 14 standard underwriter fire pumps, the four sewage pumps and the smaller pumps for the fountains. In the space beneath the cascades will also be located a lighting plant and special apparatus for throwing light of different colors on the back of the falling sheets of water. In fact the electric lighting of the cascades is to be made a special feature of the illumination or decorative lighting.

FIG. 4. STEAM SHOVEL WORK ON THE SITE OF THE LOUISIANA PURCHASE EXPOSITION.

POWER PLANT.

Steam for power purposes will be furnished by boilers ranging in size from 150 to 1,000 HP., supplied by various domestic and foreign makers. Some of these will have forced draft and others induced draft, while still others (it is proposed) will use fuel gas supplied by gas producers installed on the grounds. The fuel, for the most part, will be Illinois bituminous coal, fed by automatic stokers, special furnace appliances being used which will give complete combustion and prevent the emission of heavy smoke. The boiler house is a building about 300 × 350 ft., near the west end of the Machinery Building.

The power generating plant and pumping plant will be at the west end of the Machinery Building. The main power plant will consist of four Westinghouse steam-driven generators with an aggregate capacity of 8,000 KW., the equivalent of 10,700 HP. The exposition company has arranged to obtain 6,000 KW. (or 8,000 HP.) from the Union Light & Power Co., and this amount can be increased upon request to 7,500 KW.; in which event the total would represent 20,770 HP. Besides this, there will be an indefinite amount (but in no case be less than 5,000 HP.) developed from the exhibition plant in the Machinery Building. This current will be used for a variety of purposes.

The current supply from the two main plants

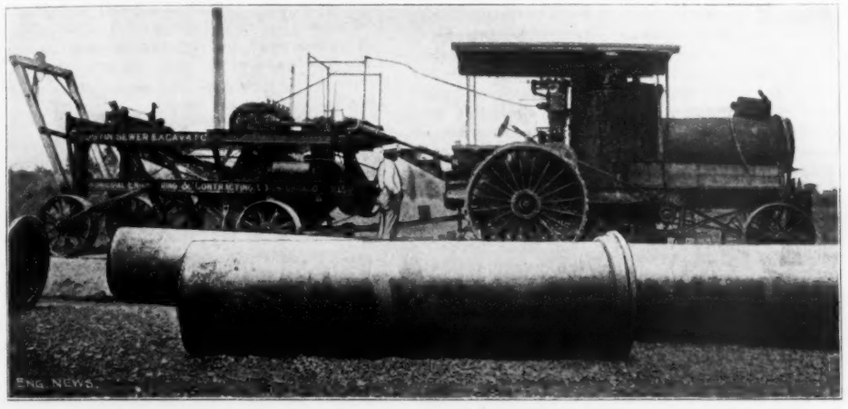

FIG. 5. SEWER TRENCHING MACHINE OPERATED BY GASOLINE TRACTION ENGINE.

above noted will be three-phase, 25-cycle, 6,600 volts, and will be so provided with switching apparatus and devices as to make each plant interchangeable in whole or in part with the other.

The distribution of energy received from the Westinghouse plant and from the local lighting company's plant will be controlled from one switchboard in the Machinery Building. This switchboard will be so arranged that circuits or services from the bus-bars can be interchanged and placed on either source of energy. The switchboard is arranged on a gallery at the west end of the Machinery Building, and is plainly in view from the main floor of the building or from the visitors' gallery on either side of the building. The several feeder and distributing circuits which lead from the main power bus-bars are taken from the building through the tower (lined with tiling) upon which the switchboard is supplied. The circuits from the generators are brought through another tower similarly consrtucted, as are also the circuits from the outside lighting company's plant, and these are brought up to connect through the proper switching devices to the main bus-bars. These two towers are situated one on either side of the main west entrance, and from them runs the 8 × 8-ft. underground conduit already referred to for carrying the cables.

The entire electrical plant will have a total generating capacity of about 29,900 KW. Of this amount 7,500 KW. will be for the interior lighting; 8,000 KW. for exterior and decorative lighting, and approximately 14,400 KW. for the uses of exhibitors and the concessions.

Gas will be supplied for operating gas engines and for other exposition purposes. This will be supplied, in part, by a distribution system, supplied for the most part by the Laclede Gas Co. and in part by individual foreign exhibitors who have signified their desire to offer gas-producing apparatus for use. Compressed air will be furnished for service purposes by isolated installations distributed among the buildings which require this service. These compressors will be operated by motors using power from the exhibitors' plant.

The exposition management has laid down a very liberal policy in its installation of exhibit machinery, and has already solicited and obtained propositions for furnishing large steam units of both the reciprocating and turbine type, as well as gas engines of considerable size, each complete with its electrical and boiler complement. The boiler units will be placed in a general boiler house, about 300 × 350 ft. This entire exhibit installation is to be used in the service of the exposition for whatever purposes will serve to demonstrate electrical and machinery practice to the best advantage. The engines, generators and apparatus already obtained on an exhibit basis guarantee that this plant will be of at least 14,000 KW. capacity and a determination is being rapidly made as to what purpose each complete outfit will be applied to in the exposition service.

Because of the size of the exhibit buildings it has been necessary to establish a transformer substation in each. In these substations will be located whatever transformers and rotaries are necessary to the service in this particular building. The apparatus in these stations will be suitable for transforming the current from 6,600 volts to the pressure required, and as it approaches high-tension line practice the switchboards and controlling devices must be of a high order of apparatus and not like the outfit usually installed in exposition work.

All the work of installation and operation will be done by the exposition management, except such wiring as is necessary to take care of the individual requirements of the concessions, exhibitors and other customers on the grounds. The provision which has been made for the exhibitors, concessions and state and foreign consumers is no inconsiderable part of the amount of energy which has to be supplied, but the means by which these consumers will be supplied and the characteristics of the energy to be delivered have not been taken up in detail. In general, forms of energy will be provided which it is thought will best serve the requirements of those who are on the grounds as customers of the exposition plant.

ILLUMINATION.

A special feature of the exhibition will be the extent and manner of the use of artificial light, both for purposes of illumination and decoration.

About 15,000 KW. will be required for the electric lighting system, of which 8,000 KW. will be for the grounds and exterior of buildings, and the remainder for the interior lighting.

Particular attention has been given to the question of avoiding obtrusive supports for outdoor lights, which would interfere with the artistic effect of views of the buildings, etc., and arrangements have been perfected in which comparatively few posts at long intervals will be required, while at the same time the units of illumination will be of small candle power. The outdoor illumination will be effected for the most part by incandescent lamps, and the greater number of these will be arranged upon the buildings and structures in such manner as to bring out the features of the general architectural scheme. The lighting of so vast an area by means of incandescent lamps is in itself a problem requiring considerable thought for its proper solution. It is not merely the question of considering illumination from the basis of the unit candle-foot; but the question of the general appearance when viewed from a distance, and the question of harmonizing the emphasized architectural lines, are both of importance in this consideration. The waterways of the exposition are of great extent and must be thoroughly lighted for the reason that they will be used for boat traffic by night as well as by day. There will be lights around the lagoons in order to facilitate this traffic, but these lights will be kept very low.

The question of the interior illumination has not yet been definitely decided, although in all probability it will be largely handled by means of arc lamps or other lamps of high candle power. On interiors the question of decoration in light does not appear to such a large extent as it does on exterior work, and the question of economy of illumination comes into prominence. For this reason larger lighting units are permissible and effective.

The great center of decorative or spectacular illumination will be the slope behind the great basin, with the cascades and the colonnades, as already described. These will form a "picture" some 3,000 ft. wide and 500 ft. deep. Besides the numerous fixed lights, the falling water will be illuminated from behind by beams of light of changing colors, as noted in the foregoing description of the cascades. For this purpose, very elaborate schemes are being worked out for combinations of color effects for the cascade and the outdoor lighting of the central portion of the exposition. One of these effects, in particular, will be the use of the new Cooper-Hewitt lamp to illuminate the flowing water with a phosphorescent appearance in the glow of molten silver.

ENGINEERS AND CHIEFS OF DEPARTMENTS.

The general organization of the exposition management has already been described, and the organization of the civil engineering department has also been given. The following list of the men who are in charge of the construction and equipment work, and of the work of obtaining and installing exhibits, will be of interest, not only for reference, but also as giving credit to the men to whom have been entrusted the onerous duties of building the exposition and providing the exhibits. The late Mr. David P. Jones, M. Am. Soc. M. E., was Consulting Engineer. The names of the architects we defer until a later article upon the buildings:

DIVISION OF WORKS.

Isaac S. Taylor	Director of Works.
Richard H. Phillips	Chief Civil Engineer.
Henry Rustin	Chief Mechanical and Electrical Engineer.
Philip J. Markmann	Chief Building Engineer.
Robt. M. Greene Assoc. M. Am Soc. C. E.	Structural Engineer.
W. H. H. Weatherwax	Chief Building Draftsman.
George E. Kessler	Chief Landscape Architect.
E. L. Masqueray	Chief of Design.
G. W. Ristine	Director of Transportation.

DIVISION OF EXHIBITS.

Fred'k J. V. Skiff, M. Am. Inst. Min. Engrs.	Director of Exhibits.
John A. Ockerson, M. Am. Soc. C. E.	Chief of Liberal Arts.
Thomas M. Moore	Chief of Machinery.
Milan H. Hulbert	Chief of Manufactures.
J. A. Holmes, M. Am. Inst. Min. Engrs	Chief Mining and Metallurgy
David T. Day, M. Am. Inst. Min. Engrs.	Honorary Chief of Mining Metallurgy.
W. E. Goldsborough, M.Am. Inst. Elec. Engrs.	Chief of Electricity.
Willard A. Smith, M. W. Soc. E.	Chief of Transportation.
Howard J. Rogers	Chief of Education, Social Economy and International Congresses.
Halsey J. Ives	Chief of Art.
Frederic W. Taylor	Chief of Agriculture and Horticulture.
Tarleton H. Bean	Chief of Forestry, Fish and Game.

ENGINEERING NEWS

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

What is the actual cost of street lighting in New York City to-day? To what extent are the street lighting companies overcapitalized, and what is the effect of that overcapitalization on the street-lighting branch of the service rendered by the companies? These are the real questions at issue between Commissioner Monroe and the lighting interests, and they are entirely ignored by Mr. John M. Bowers, attorney for the Consolidated Gas Co., in the statement abstracted elsewhere in this issue. Incidentally, it is only fair to say, Mr. Bowers does state that public lighting is less than 4% of the entire business of his company, which leads one to believe that the service must yield a handsome profit, or else the company would not fight so hard against the proposed legislation enabling the city to establish a street lighting system of its own.

It was because no figures of cost of service in New York were available that Commissioner Monroe was compelled to gather such information as he could on the cost of street lighting in other cities. Obviously, this is not a scientific way of testing the fairness of lighting charges in New York, owing to the variations in local conditions in different sections of the country, and to the fact that actual cost of service, plus a fair return on capital legitimately invested, is the real criterion. But in the absence of cost figures in New York, and in view of the large quantities of water in the capitalization of the lighting companies, there is much to be said in defense of comparative figures from other cities. Perhaps the strongest defense of all is Commissioner Monroe's statement, given in our abstract, that "cost of fuel, length of contract, and number of lights" does not appear to affect the prices paid for street lighting in other cities, but that "each city seemed to pay what it was willing to or what it had to." The same general conclusion in regard to water rates for domestic service was reached in the introduction to "The Manual of American Water-Works" for 1889-90, where, after comparing the average charges per family and cost of works per family for municipal and private works, it was stated:

> We see by making such a comparison that the cost of the works has little to do with the variation in price, and certainly does not constitute the reason why private works charge more than public.

Nevertheless, common sense and justice demand that such haphazard methods of reaching conclusions as to the proper charges for public service be avoided where possible, and that the accounts of public service corporations be made not only public, but subject to public supervision.

Finally, the Consolidated Gas Co. has made a very poor defense of its charges for street lighting, and has advanced no valid argument against the establishment of a municipal lighting system by the city of New York.

There is such a scarcity of information on the appraisal of water and lighting plants about to be purchased by cities that the report of the appraisers of the property of the Bienville Water Supply Co., of Mobile, Ala., printed elsewhere in this issue, possesses much interest and value. It is all the more interesting and valuable because the city has built a plant of its own, thus giving rise to a ruinous competition, and because both the report, and the explanatory letters from each of the three appraisers, state the principles upon which the appraisal was based. On the other hand, there is a local element in the appraisal which lessens its general applicability to other cases, since the appraisers felt themselves bound by a court decision to the effect that the city could not neglect the value of the tangible or physical portion of the property of the company; while the court had also decided that the company did not possess an exclusive franchise. In accordance with this decision, which Mr. Alvord, at least, seems to adopt as a principle worthy of general application, the appraisers fixed the value of the works of the company at their cost of reproduction, less depreciation. The report merely states the total amount of the latter, giving no information as to how it was reached. It would be interesting to know how the appraisers arrived at 12% on the total cost of reproduction, for a water-works plant built 15 years ago. Another striking feature of the appraisal is that, on the basis of valuation assumed, the price at the time the city built its works, about 1900, would have been $376,412, instead of $606,689, as laid down in the report. If, as the appraisers, or some of them, believed, and as all of them agreed, in deference to the court decision, the company is entitled to the value of its physical plant, can a method of appraisal be just that allows such fluctuations in value? We do not express an opinion but merely suggest the question. Finally, since it is admitted that if each of the two competing plants were owned by private companies, neither would ever be expected, much less compelled, to pay more than the revenue-producing value of the other plant, is it or is it not justice to compel the city to pay the present value of the physical property in order to stop a ruinous competition? Of course the element of forced sale enters here, besides the moral obligations already noted.

One of the problems on which the law is yet to be defined concerns the duties of a railway company which is offered more traffic than it can handle. Its legal obligation as a common carrier is of course to treat all patrons alike; but whose freight shall be refused and whose shall be accepted when exigencies compel a choice to be made? That is the very practical and important problem which has recently confronted several of the railway companies which operate lines of heavy traffic. The common carrier is well known to be obliged to furnish his services to all who apply for them, so far as his abilities permit, and in the old days the problem was simply solved by the old rule of first come, first served. Those who came to the place of starting of the stage coach after the vehicle was full had to postpone their trip. No such simple solution is applicable to a surplus of freight traffic.

When the railway cannot carry all the traffic offered, it has to consider first of all its duties as a servant of the public. Perishable goods, of course, are entitled to precedence over those which are not injured by delay; and the immediate necessaries of life, such as flour, provisions, coal, etc., will naturally take precedence of coke, or and lumber. Of course such action is discrimination, but it is discrimination for which a good defense can be made. The railway is a public servant, and its first duty is to the public. Because the hardship will be most serious if shipments of food and fuel were held up, the railway company may rightfully discriminate in favor of these and against those who want to send or receive shipments of ore or lumber or iron.

Recently in the Northwest a new form of discrimination has appeared. The lumber shipments from the mills of Washington and Oregon eastward have become so heavy that the railways cannot furnish cars enough to meet the demand. A Tacoma dispatch to the New York Times states that 289 new saw mills and shingle mills have been built during the past 15 months in the state of Washington alone, and that last year's eastbound lumber shipments by rail amounted to 69,560 carloads.

To cope with the situation the railways have served notice that shipments for points east of Chicago will not be accepted unless loaded in foreign cars. Apparently the railways want to avoid the loss of their cars to their eastern connections, and they may fairly claim that that order is in the interest of the lumber dealers themselves, since the more home cars are sent east on long journeys, the smaller the supply of cars available for the lumber trade.

A curious and perhaps not entirely unforeseen result of the order, however, is that a stimulus is to be given to westbound transcontinental traffic. The lumbermen who find their shipping facilities thus restricted are using every influence to induce Pacific Coast merchants to have their goods sent from the East by rail and not by water, in order that the cars may be available for return lumber shipments.

In our issue of March 5 we referred to the proposed Georgian Bay Canal, which, as our readers will remember, is planned to furnish a direct waterway, 21 ft. in depth, from Lake Huron to tidewater at Montreal, via the French River and the upper Ottawa. We then reported the strong probability that the project will receive financial assistance from the Canadian government.

Last week the subject was brought up in the Canadian parliament and a statement regarding it was made by Sir Wilfrid Laurier, the Premier. It is printed as follows in the "New York Tribune:"

> The subject brought up by Mr. Murray (the Member for Pontiac) is not exactly new, and I don't know that I can add anything to the declaration which the government has made on a previous occasion. Mr. Murray is aware that a company was chartered by this Parliament to construct what is called the canalization of the Ottawa River and the French River from Georgian Bay to the waters of the St. Lawrence. I think that I may safely say that it was never expected that this company would be able to perform such a gigantic task unassisted. For my part, I think that the country would be justified in making a moderate expenditure of money with the view of providing another means of communication between the East and the West. The route of the Ottawa River is undoubtedly the natural channel of communication between the East and West. It was the route followed by the old voyageurs in the early days of the colony. When the Northwest produced nothing but furs it was the route followed by the fur traders to bring the products of the West to the Eastern shores. Whenever a company is prepared to approach the government asking for what I call reasonable assistance I think the government will be prepared to hear the application favorably and to ask Parliament for a reasonable assistance. It seems to me that there is a great deal to be said in favor of the view taken by Mr. Tarte in favor of the government itself undertaking the full development of the French River from the waters of Georgian Bay to Lake Nipissing. If that were done, it would be a means of having another port on the lakes, and it would undoubtedly contribute to solve the problem of the transportation of the products of the Northwest to the seaboard.

Doubtless the promoters of the New York barge canal enterprise will try to construe the Canadian scheme as an argument in favor of their 12-ft. waterway; but such an argument is fallacious on its face. To build a 12-ft. channel for canal boats to compete with a great deep waterway, accommodating the largest steamers on the lakes, would be like building a horse-car line to compete with an electric railway.

SUBLETTING CONTRACTS.

A correspondent who took part in the discussion on the relation of engineers to contractors in our issue of March 5 voiced a feeling which is by no means uncommon. He urged that subcontracting should be discouraged and indicated that he would like to see it abandoned. It seems to us that there are two sides to this question.

Few engineers who have not been themselves contractors appreciate the mental strain a contractor is under while he has an extended piece of work in progress. This mental anxiety is very largely due to the fact that thoroughly capable foremen are in limited supply. The foreman who will hustle work for his employer as he would for himself is a rare bird. Long years of experience have taught most contractors that even the best foremen accomplish more work when they become subcontractors. Then it is their own money that is being saved or wasted, and their wits are sharpened to devise methods of more cheaply handling work. They are quick to "fire" a loafer for whom they have no sympathy when his loafing means money taken from their own pockets.

In a word, subcontracting has been found by experience to result in the doing of work at less cost, and the greater and more extended the work the more advantageous does subcontracting become.

There is a physical limit to the endurance of the contractor himself in looking after a long stretch of railway work for example, and a mental limit, too. Few engineers can appreciate the relief that comes to the contractor from a knowledge that each section and each class of work has been sublet to hustling subcontractors.

It is quite true that subcontracts are often taken at too low a figure—so are the whole contracts for that matter—and the engineer is continually appealed to for "extras," or annoyed by skimped work, as a consequence. This, however, is not a good argument against subcontracting. The difference between the price paid the contractor and the price he pays his subcontractors should not be regarded as money lost by the railway company—a sum that might have been saved by letting work to the subcontractors direct. Instead of paying his subcontractors salaries as foreman, the contractor pays them the profits they make. The contractor in turn is paid by the company, not in salary, but in profits. He is in reality the general business manager of the work. He is paid for his knowledge of where to find good men who can boss or handle the work—and this knowledge is in fact one of his largest assets. He is paid for his ability to handle those men, to buy materials, to furnish the necessary plant, to furnish capital, etc.

Of course it is true that no rule can be laid down which will fit all cases; and we are far from saying that subcontracting is in all cases a benefit. In what we have said above, we have referred only to the case in which one large contract is sublet in small sections, a common practice on railway construction work. Another sort of subcontract, where a general contract is taken by one party and turned over for execution to another party, is not seldom met with by engineers, and we know of nothing that can be said in its favor. Such arrangements are as a rule the cover for a fraud on the parties who pay for the work. Contracts should not be let to men unless they are able and willing to actually undertake the work, and if through some unforeseen circumstance they are unable to do this after taking the contract, it is in a majority of cases better to cancel that instrument and make an entirely new contract with a party with whom the engineer can deal direct.

Again, it may be laid down as a general rule that contracts should not be let for work so large in amount as to prevent competition by bona-fide contractors. The sure result of such a plan is to throw the work into the hands of financiers who then proceed to divide the work up into sections and relet it to actual contractors.

A valuable object lesson on the results of these two methods is furnished by the work of subway construction in Boston and in New York. Boston, when she set about building her subway, cut up the work into small sections, which were let under sharp competition, and the work was carried out at a very low price. The men in charge of New York's affairs, when the legislation for the Rapid Transit Railway was framed, were very much afraid of the "municipal trading" bugaboo, and they concocted a plan under which the city loaned its credit to a private corporation, which was to construct and operate the road.

This corporation, it is estimated, will make a profit of $6,000,000 on its $35,000,000 contract for the work of construction on Manhattan Island.

Another illustration is the often repeated rumors that this or that syndicate is to make a bid for the entire construction of the Panama Canal. Engineers know that to let any such huge work in a single contract is contrary to sound business principles. Such a course is often advocated, in connection with great public works, but a search will usually disclose that the influence behind the plan is the party who expects to reap an "unearned increment" from the handling of the contract.

LETTERS TO THE EDITOR.

A Canadian Deep Waterway to the Sea.

Sir: In view of the articles in your issue of Feb. 26 and March 5 on the canal question, it may interest you to know that the Canadian Government has now before Parliament a bill to authorize the spending of $5,000,000 on the improvement of French River, I. e., to make it navigable to Lake Nipissing. This is the western end of the Montreal, Ottawa and Georgian Bay Canal.

Truly yours, T. Craig.

1013 Sherbrooke St., Montreal, Canada

One of the Dangers of Cast-Iron Columns.

Sir: Enclosed you will find a photograph showing a cast-iron column, which illustrates very forcibly one of the uncertainties that an engineer has to contend with when using cast columns in construction. The column

An Object Lesson on Cast-Iron Columns.

in some way evidently became filled with water and frozen, cracking as shown. Had this column been inside a partition, or covered in any manner from view, the crack would not have been discovered. Yours very truly,

Wm. R. Kales.

Beecher Ave. and M. C. R. R.,
Detroit, Mich., April 10, 1903.

The Effect of Forests on Floods in Large Streams.

Sir: I wish to endorse your position relative to the effect of forests on floods, as set forth in the leading editorial of the issue of the Engineering News of April 9. My observation has led me to believe that even on many of the smaller streams of the West the removal of the timber from the headwaters does not affect the volume of high water, but that the maintenance of the forests in these regions greatly enhances the value of the streams as a source of supply for the irrigator, as the low water discharge is greater and steadier.

In connection with this matter it might be said that it will probably never be possible to control the discharge of the larger streams of the country through the construction of storage works. This is one of the popular fallacies, but those who advocate such a policy cannot have considered the problems which would confront engineers should this be attempted. The largest reservoir in the West to-day has a storage capacity of something like 120,000 acre-feet. This reservoir covers an area of 6,000 acres to a depth of 20 ft., and it is nearly 40 miles around its shore line. The Ohio River at high water would fill such a reservoir in 1½ hours, at the most.

Sincerely yours, Clarence T. Johnson,
Assistant Chief Irrigation Investigations.

Cheyenne, Wyo., April 12, 1903.

The Pay of Aids on the U. S. Coast and Geodetic Survey.

Sir: In your issue of April 9 you publish a letter from Oliver B. Harden on the pay of engineers connected with the U. S. Coast and Geodetic Survey. While your comment at the end answers in the main his contention, there is a point that I desire to take up, namely, "Uncle Sam's sharp practice."

How many of the Aids at $720 accepted the position under compulsion or protest? How many would, if it were possible, exchange their position for that of Miss Prettyman with several years' time and expenditure to the good? Probably not a single one. If there is sharp practice here, then it is universal and common to us all. We do not refuse to buy a commodity because its price is low.

I think that engineers of wide experience will agree with me that in the lower ranks of the profession there are more men paid more than they are worth than paid less. And this is natural and proper, for the man who makes himself plainly worth more than he is paid will not have to stay in the lower ranks.

Any injustice that can be laid at Uncle Sam's door in regard to pecuniary reward shows itself at the other end of the line. A small beginning may not seem agreeable, but its value in making men is often in proportion to its size. Yours truly,

G. M. B.

Salt Lake City, Utah, April 15, 1903.

A Projected Water-Balance Incline for Hoisting Freight Wagons.

Sir: In your issue of March 19, I note an article commenting on a novel inclined plane in California, on which the products of a quarry are taken up the side of a mountain by the overbalancing power of a barrel of water placed in the descending car on the opposite track.

In 1892, while the writer was one of the Assistant Engineers of the Arrowhead Reservoir Co., in San Bernardino county, Cal., the company was building a very expensive road to its main reservoir site in the San Bernardino mountains, for the purpose of transporting large quantities of construction material. Owing to the long, hard climb, in order to overcome an elevation of some 6,000 ft., a four-mule team could make but two round trips a week, carrying a ton at each trip, and the writer suggested to the company the construction of a double-track inclined plane directly up the side of the mountain, with cars of a sufficient size to take a four-mule team and wagon, thus enabling said team to haul two tons at a trip and to make the round trip in a day. It was proposed to operate the inclined plane by conserving the water from a spring nearby in a reservoir at the head of the incline and by utilizing the triangular space between the level floor and the inclined trucks of the cars as a balancing tank, arranged to automatically fill at the top of the grade and discharge at the bottom, thus leaving the car floor unincumbered.

The plan was not seriously considered by the company because it thought too much money had already been spent on the road to justify its abandonment. At that time the writer believed the idea to be an original one, but has since learned that at that time a number of just such water-balance inclines were in use in Switzerland.

Very truly yours, Arthur S. Hobby,
General Manager and Chief Engineer.

Ferro-Carril de Guantánamo, Guantánamo, Cuba,
April 7, 1903.

Concerning the Election of Members in the American Society of Civil Engineers.

Sir: The subject of the growth of the various engineering societies of America has recently been commented upon in your paper and the growth of the Society of Civil Engineers was contrasted unfavorably with that of the Society of Electrical Engineers.

I submit the following as my experience with the Society of Civil Engineers, thinking possibly it may furnish a text for other comments:

Some years ago I made application to the Society for

admission as a member. I am a graduate of a technical school and considered that I had had the necessary experience. My application was approved and my experience was deemed sufficient by the Board of Direction of the Society and my name was passed to ballot in the grade of member, with the result that I was rejected.

I immediately applied for a reconsideration ballot, and when making the application, every member of the Society with whom I am acquainted in any way, wrote the necessary letter for such reconsideration. One member of the Society, the engineer of a large steel plant, who was unknown to me, wrote the Board of Direction certifying to the good character of a steel building which I had designed and which his company had built. His letter was unsolicited and was written without my knowledge. He had merely seen my name attached to the drawings.

Notwithstanding that I had the endorsement of every member of the Society whom I had ever met, I was again rejected, and since then I have let the matter rest. I never knew why I was voted down. There is no way of finding out why a rejection is made and the only recourse one has is to air his views in your paper.

Such treatment as I received makes a man chary about applying for membership in the Society, where seven negative votes can reject him. This is especially true if he meets with such an experience as mine. The injustice of the rejection which I experienced would seem to mean that some other way should be taken for electing members. Very truly yours

Injured.

A Circular Inquiry to Engineers.

Sir: I send you enclosed a circular letter and blank received through the mail to-day from the "Engineering Company of America." As you will see, I am asked to fill out on this blank my professional record and forward it to this company; yet the company does not, it will be observed, give any information about its character or objects, nor does it state for what purpose the information asked is to be used, nor does it give any sufficient reason why the persons thus honored should comply with this modest request. Furthermore, it does not even enclose a stamp for return postage.

As many others of your readers have doubtless been favored with copies of the circular, will you not kindly enlighten us upon the subject.

Civil Engineer.

New York, March 9, 1903.

(We referred the above letter to the Engineering Company of America and append the reply received as follows:—Ed.)

Sir: Regarding the question raised in your letter of March 11th, we would answer it as follows:

We are constantly having inquiries regarding different engineers throughout the country as to their professional standing, references, etc. In order to be able to meet these inquiries and also to, as far as possible, come in touch with all engineers throughout the United States we are preparing a directory of these. The enclosed blanks will give you an idea of the questions we are asking each and the letter which accompanies our request. Thus far we have been favored with replies in nearly all cases and we hope in the near future to have our directory of engineers with references, etc., very complete.

Although we have a large staff of engineers who are associated with us in one way or another, yet occasions are constantly arising when we require the services of an engineer outside of those with whom we already have some agreement and by referring to our directory of engineers we know where to correspond with those whom we think would meet our requirements.

Yours very truly,

Engineering Company of America,
By Joseph Hyde Pratt, Secretary.

74 Broadway, New York, April 17, 1903.

The Harbor Improvement at Cumberland Sound.

Sir: In my communication in reference to the Cumberland Sound Improvement (Eng. News, March 26), I misunderstood the statement in your editorial. Your words were:

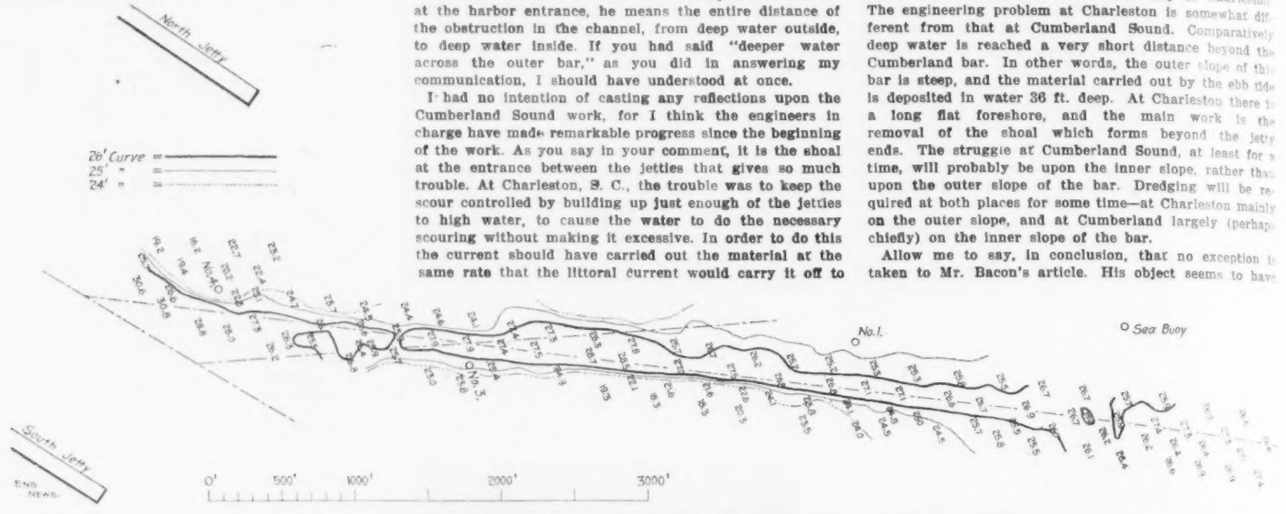
Captain Gillette began work two years ago . . . he has made a harbor entrance at Cumberland Sound with deeper water "across the bar" than any other port on the South Atlantic coast. The depth at low tide is now over 25 ft., and it is steadily increasing without dredging.

In Southern seacoast cities when one speaks of the bar at the harbor entrance, he means the entire distance of the obstruction in the channel, from deep water outside, to deep water inside. If you had said "deeper water across the outer bar," as you did in answering my communication, I should have understood at once.

I had no intention of casting any reflections upon the Cumberland Sound work, for I think the engineers in charge have made remarkable progress since the beginning of the work. As you say in your comment, it is the shoal at the entrance between the jetties that gives so much trouble. At Charleston, S. C., the trouble was to keep the scour controlled by building up just enough of the jetties to high water, to cause the water to do the necessary scouring without making it excessive. In order to do this the current should have carried out the material at the same rate that the littoral current would carry it off to the southward. It was so far out to deep water at the Charleston entrance that a very slight shoaling would cause trouble, and this is what occurred. The swiftly moving current between the jetties would bring down quantities of material and deposit it at the mouth or a little beyond, faster than the littoral current would take it away. The only way to keep the entrance open, therefore, was to put a dredge to work on this shoal. This was done in 1891, the government having a dredge built for the purpose.

The conditions seem to have been much more favorable at Cumberland Sound. At Charleston it is several thousand feet from the ends of the jetties to the five-fathom curve, but at Cumberland Sound it is only about 3,000 ft. now from the end of the North Jetty and it was much nearer in when the work was started. On this account a considerable shoaling could take place without doing any harm. That such shoaling did take place to some extent is shown by the fact that the contours at the mouth of the channel have moved outward about 2,000 ft. since the beginning of the work. I believe if the South Jetty had been built out with the other that there would have been the same trouble as at Charleston on account of the current bringing out the material faster than it would be carried away southward by the littoral current. If the South Jetty is ever built out near to the line where the North Jetty ends, it will probably cause too much scour and form a bad shoal across the entrance. By dredging on the inner shoal a fine channel can soon be obtained and will probably maintain itself without any more trouble, and the experiment is certainly worth trying before running the risk of spoiling the good work by completing the other jetty. Very truly yours,

Walter M. Smith, Assoc. M. Am. Soc. C. E.
U. S. Engineer Office, Portland, Me., March 30, 1903.



SOUNDINGS IN EASTERN CHANNEL, CHARLESTON HARBOR, S. C., MARCH 9, 1903.
Soundings are shown reduced to mean low water. Portions of 24' and 25' curves are put in from November surveys.

Depth of Water on the Charleston Outer Bar.

Sir: In your issue of March 12 you published a paper by Mr. James H. Bacon, Assistant Engineer, on "The Improvement of the Entrance to Cumberland Sound, Georgia and Florida," and you say editorially of the officer in charge, "he has made a harbor entrance at Cumberland Sound with deeper water on the bar than any other port on the South Atlantic coast."

Mr. Walter M. Smith called your attention to the fact that this statement is likely to give the impression that the channel entrance at Cumberland Sound is deeper than that of any of the South Atlantic harbors, while, as a matter of fact, the entrance to Charleston Harbor is superior to the Cumberland entrance. In your notes upon Mr. Smith's letter you maintain the essential correctness of your former statement, but do not seem to recognize or admit its rather misleading character. It is believed that you intended no injustice, although the decided superiority of the Charleston entrance is still ignored.

My object in writing you is to present distinctly and definitely the claim of Charleston Harbor to having, at present, the deepest entrance of any of the South Atlantic harbors. I enclose a blue print of recent soundings on the outer shoal, over what is now the shallowest part of the entrance to this port, on a scale of 1 in. to 500 ft. The shoalest sounding upon the lighted range is 25.9 ft. at low water, with a mean rise of 5.2 ft. At Charleston the project under which the work is being done is designed to secure 26 ft. at mean low water and 600 ft. wide ultimately. Very nearly the required depth has been obtained on the axis of the cut, and there is a good channel at least 25 ft. deep at mean low water and 200 ft. wide, from the Atlantic Ocean to the wharves of the city of Charleston. The engineering problem at Charleston is somewhat different from that at Cumberland Sound. Comparatively deep water is reached a very short distance beyond the Cumberland bar. In other words, the outer slope of this bar is steep, and the material carried out by the ebb tide is deposited in water 36 ft. deep. At Charleston there is a long flat foreshore, and the main work is the removal of the shoal which forms beyond the jetty ends. The struggle at Cumberland Sound, at least for a time, will probably be upon the inner slope, rather than upon the outer slope of the bar. Dredging will be required at both places for some time—at Charleston mainly on the outer slope, and at Cumberland largely (perhaps chiefly) on the inner slope of the bar.

Allow me to say, in conclusion, that no exception is taken to Mr. Bacon's article. His object seems to have been to show the splendid results of Captain Gillette's work rather than to institute a comparison with other government work on this coast.

James P. Allen.

Charleston, S. C., April 2, 1903.

(It was not our intention, in the editorial comparison to which our correspondent takes exception to reflect upon the conduct of or the results obtained in any other similar work. It is obvious to any engineer that no two harbor entrances are duplicates of each other; and even though there may be an outward similarity, one site may prove as difficult of treatment as the other is easy. Our comparison was simply intended to show what a good channel had been made across the outer bar at Cumberland Sound, and to show it, not merely by feet of depth but by comparison with other existing harbor entrances in the same locality.

So far as this comparison is concerned, it should be said that our data for Charleston were taken from the last published report to the Chief of Engineers. From the above statement by Mr. Allen it would appear that Charleston has now almost 26 ft. across the bar, which would make its channel deeper than that last reported over the outer bar at Cumberland Sound.—Ed.)

American and European Formulas for the Flow of Water Over Weirs.

Sir: In going over some articles on hydraulic development, by Mr. Thurso, published by you in December, 1902, I am very much impressed with a statement made by him to the effect that the American formulas for flow of water over weirs are inferior in accuracy to the similar formulas used by European engineers.

As one very much interested in this particular question, I venture to request that some definite information be given as to the facts in this matter. For instance, I have been taught to rely implicitly upon certain formulas given in the fifth edition of Merriman's "Hydraulics," published in 1895. Article 53, pp. 107 to 110, inclusive, contains a formula for contracted weirs, which is certainly generally understood in this country to be quite reliable.

I should greatly appreciate it, and cannot but believe that others similarly interested in the matter would also appreciate it, if your paper will carry this matter a little

further for the information of those who are not conversant with European practice, and who yet desire to make hydraulic work in America as accurate as in any other country. Respectfully,

F. D. Olmsted.

Provo, Utah, March 31, 1903.

(A proof of the above article was submitted to the author of the paper referred to and we append his reply as follows:—Ed.)

Sir: If Mr. Olmsted will look up the passage in question in my article in Engineering News of Dec. 4, 1902, he will no doubt note that I have refrained from giving any opinion of my own in this matter. What I have said is that the results of Holyoke and European tests cannot be compared with each other, as the same turbine will give different results when tested in Europe from those obtained at Holyoke, and that European engineers claim this difference to be due to the different methods of water measurement, etc.

Mr. Olmsted will find the desired definite and detailed information in regard to this matter in the paper published by the German Society of Engineers (Zeitschrift des Vereins Deutscher Ingenieure) as follows:

Description and illustrations of testing flume, also method by which the coefficients for same were obtained, page 1062, Vol. 1892.

Description of the tests made by Prof. Pfarr and their results, from which the figures given in Engineering News were taken, issue of June 7, 1902.

Defence of the Holyoke test by Mr. Clemens Herschel and reply to same by Prof. Pfarr, issue of Nov. 22, 1902.

In the latter issue, I believe, are also several references to articles on this subject, which had previously appeared in the publication named. Mr. Pfarr, although now a university professor, has been for many years chief engineer of the works of one of the largest turbine builders in Europe. He has always been keenly alive to all progress in turbine construction, and it is principally due to his efforts that the manufacture of the Francis turbine was taken up by European builders.

Last year, in an address delivered before the American Institute of Electrical Engineers by Dr. Perrine, President of the Stanley Electric Co., it was stated that owing to the change of a pipe and an uncorrected formula, the results of tests made in one of our best known testing flumes have been at fault for the past five years. (See Eng. News, Aug. 21, 1902, p. 134, middle column, near the bottom.)

This matter is certainly of importance, and perhaps some of your readers can give some further information on the subject, as I was unable to obtain it.

It would be interesting to know which testing flume was referred to by the above remark. Was the error a serious one and was it in favor of or against the turbine builders? Also have the parties in charge of the testing flume informed all those for whom such faulty tests were made and returned the money paid for same, and have builders of turbines, who may have printed these test results in their catalogues or circulars, removed such erroneous test results from their printed matter since the mistake has been found to exist? Yours truly,

John Wolf Thurso.

75 Common St., Montreal, Canada, April 13, 1903.

(We also submitted the letter of Mr. Olmsted to one of the foremost American authorities on formulas for hydraulic computations, and he has furnished us the following statement in reply to Mr. Olmsted's query. We regret that we are not at liberty to quote his name:—Ed.)

"The weir formula generally used in this country prior to 1888 was that of Weisbach, and I believe this is still mostly employed in Europe. In that year Hamilton Smith, Jr., published an exhaustive discussion of all recorded weir observations, and deduced coefficients for use in different formulas, and these formulas and coefficients have since been so widely used in this country that they have largely displaced those formerly in use. The formulas of Smith do not possess the theoretic accuracy of those of Weisbach, but they are more convenient for numerical computations. Smith's coefficients were deduced for his own formulas, however, and cannot be used in the European formulas. Owing to the complete investigation made by Smith, which included weir measurements covering a greater range than those considered in the older discussions, his formulas when used with his coefficients are regarded by authorities in hydraulics as giving more reliable and accurate results than can be obtained from the European formulas and tables. This subject is briefly mentioned in Merriman's "Hydraulics," where it is said on page 104 of the seventh edition, referring to Smith's formulas, that

the above formulas are not in all respects perfectly satisfactory, and indeed many others have been proposed. The actual discharge differs, however, so much from the theoretical that the final dependence must be upon the coefficients deduced from experiments, and hence any fairly reasonable formula may be used within the limits for which its coefficients have been established.

"As I understand the matter, the best hydraulic formulas are not necessarily those theoretical ones which are deduced by disregarding frictional resistances. Kutter's formula for channels, for instance, has practically no theoretical basis, but it is more widely used than any other because it was deduced from a wide range of observations and because its coefficients of roughness enable it to be applied to all kinds of conduits and streams. Smith's formulas for contracted and suppressed weirs are modifications of the theoretic weir formula which take account of the velocity of approach in a different way, and which appear, in connection with his coefficients, to give the most accurate results now obtainable."

Capt. Mahan's Defense of the Metric System.

Sir: Noting the references to my paper, "The Metric System," by Mr. F. A. Mahan, in your issue for April 16, I take occasion to make reply.

After a recital of the history of the system, we have again the standard illustration of its superiority, the calculation of the weight and volume of a tank of water, followed by the statement: "This superiority in matters of calculation runs all through."

It does nothing of the kind. The fact that the unit of weight is that of a cubic decimeter of water leads to a simplicity in calculations relating to water that goes with no other substance. The cases in which the interrelations of the units of length, weight and capacity lead to any saving of time in calculation do not, probably, comprise 1% of the calculations which mechanical engineers, at least, have to make.

Mr. Mahan next tells us that he has lived for more than four years in France, Belgium and Germany and has nowhere found anything but the metric system in use. He must have kept his eyes shut. I have shown by evidence piled on evidence that France is as full of her old units as a bed tick of feathers.*

We are next given a list of the objections raised against the metric system as follows:

1. "That the meter is not 1-10,000,000 part of the earth's quadrant." I know of no one who seriously considers this to be an objection.

2. "That the cubic decimeter of water does not weigh a kilogram." I know of no one who seriously considers this to be an objection.

3. "That with the metric system binary fractions cannot be used," and we are asked, "why write ½ rather than .5, ¼ than .25, or ⅛ than .125?" Mr. Mahan should not have stopped here. Why write .3333 + rather than ⅓, or .1666 + rather than ⅙? If your readers will multiply some number by .3333 + and then by ⅛ or even by .25 and then by ¼ they will have an excellent example of the universal superiority of decimal fractions.

4. "In using millimeters instead of decimals of a meter we are adopting a second unit." I know of no one who raises this objection. The objection to the millimeter is that it is inappropriate to the large dimensions for which it is used and this objection is valid.

5. "The arc, to be consistent, should be divided decimally. Why?" Because just as strong a case can be made against dividing the degree into 60 minutes as against dividing the foot into 12 ins., and because the most useful interrelation of all—that between angular measurements and the nautical mile—which exists in the English system is, without the centessimal division of the quadrant, lost in the metric system.

We are next told that "When manufacturers say that their whole plant will become useless by the change the statement may be laid down to an endeavor to affect opinion by means of high coloring." No intelligent man makes any such statement.

We thus see that of the six objections which are valiantly answered by Mr. Mahan four are simple men of straw, while the real objections are scarcely hinted at.

We are told, however, that Eureopean contractors "cannot use your machines; they are all built to the foot and inch" and that "American machines can be repaired nowhere except possibly in England." That is, American manufacturers can use their English plant after the adoption of the system, but nevertheless European contractors, having adopted the system, cannot use such plant! American machine shops can use their English plant in constructing and repairing metric system machinery, but European machine shops cannot use their metric plant in repairing English system machinery, and this sort of thing is presented as argument!

A lathe—English or metric—will, with equal facility, turn a shaft 1 in. or 25 millimeters in diameter and, similarly, excepting screw threads, there are few details of machinery of which repairs are not independent of the system of measurements used in their construction, *and* English pitch threads are in practically universal use in Germany and in large use in France. The ships of the Germany Navy are fitted with English pitch screw threads because the German naval authorities know that, with metric threads, repairs to threaded members could not be had in foreign ports. Thus do the German naval authorities acknowledge the universality of the English inch and thus are the advocates of "ze Grände système universelle" covered with confusion. Why are the speeds of French ships of war measured in English knots and their steaming radii in English miles? Why does every German steamer in the harbor of New York city carry upon its stem the draft marks figured in English feet?

Without knowing it, Captain Mahan gives us a leading anti-metric argument. "Few persons have any idea of the tangled and confused condition of weights and measures in Europe 120 years ago." We have no such confusion and the reasons which led to the adoption of the metric system by other nations are here entirely wanting. Nay more, this tangle is still such as to make our system the simplest of those *in actual use* in any country in the world.

Mr. J. H. Ball, a machinery manufacturer and dealer of Barcelona, Spain, where he deals in the machinery of nearly every European country, writes to the "American Machinist:" "In handling the numerous machines which I have to come across in my business, I find only two nations whose measures are always uniform in all respects, and these two are England and United States."

F. A. Halsey.

World Building, New York, April 20, 1903.

*It is proper to add that the permanent copy of my paper, which the public has not yet seen, will contain at least twice as much evidence regarding the persistence of old units in metric countries as was given in the advance copy.

AN IMPROVED FORM OF MINE WINDLASS.*

By G. Percy Ashmore.

The defects of the ordinary mining windlass are very evident. If one bucket is used, its weight is unbalanced; this dead weight may be from one-seventh to one-sixth of that of the load, and is consequently far from being a negligible quantity. The double windlass, with two buckets or kibbles, is free from objection as far as the balancing of the weight of the receptacle is concerned; but, for a given length and a given diameter of drum the depth to which the winding can be carried on is limited, because the rope in coiling up can only travel one length of the drum, no overlapping being possible. The greatest depth attainable is therefore equal to the length of the total number of coils which can be wound on the drum.

This limitation of depth is not very important for shallow workings up to 120 ft., but in out-of-the-way places where labor is cheap, the windlass is often used for hoisting from depths of 300 or even 600 ft. If the ordinary form of double windlass is employed we there-

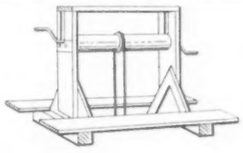


Fig. 1.

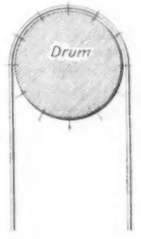


Fig. 2.

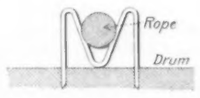


Fig. 3. ENG. NEWS.

fore require a drum of larger diameter, a very long drum or a thin rope.

The diameter of the drum cannot be increased without diminishing the proportion between the leverage of the arm and that of the load. The second alternative, the use of a longer drum, makes it necessary to sink a longer shaft, which means increased cost. The third alternative is easily possible, as a thin wire rope may be substituted for the thick hempen one. However, even with a hempen rope this difficulty of winding to a considerable depth may be overcome by dividing the drum into two halves by a collar in the middle, or by a series of pegs; each half of the drum is then supplied with a separate rope, which can be wound up so as to overlap. It is true that with each successive series of coils the leverage of the load increases, but this increase is to a certain extent counterbalanced by the greater length of free rope hanging down from the other side of the drum. Another defect is that when once the rope begins to overlap it tends to mount on to the coil just wound, and then slips back into its position on the drum. The friction between the portions of the rope caused in this manner is the main source of the wear of the rope.

A satisfactory method of overcoming the difficulty of winding to a considerable depth with a hempen rope in a small shaft is to use the improved form of windlass shown in Fig. 1. The rope only makes one-half turn round the drum, and is prevented from slipping by means of 12

*Condensed from a paper read before the Institution of Mining and Metallurgy, London, Feb. 19.

M-shaped pieces of ⅝-in. round iron, placed symmetrically round the center of the drums (Figs. 2 and 3). The angle of the M in which the rope lies is approximately 35°. The rope never touches the wooden portion of the drum, but jams in the angle of the M pieces, and so is prevented from slipping. Even if one end of the rope is hanging loosely down the shaft, and a full bucket attached to the other end, the friction is great enough to prevent any slipping.

The simple device just explained has the following advantages:

(1) The bucket travels in the middle of the shaft, and it is, therefore, possible to wind from a great depth even in a small shaft.

(2) Increased life of rope, for the main source of wear, friction between successive coils of the rope, is avoided.

(3) Smaller quantity of rope required.

ANNUAL MEETING OF THE AMERICAN ELECTRO-CHEMICAL SOCIETY.

In our account of the Niagara Falls meeting of the American Electrochemical Society, in our issue of Sept. 25, 1902, we had occasion to refer to the society as being formed of a coalition of chemists and electrical engineers. At the third general meeting of the society (the first annual meeting since its formation a year ago), held at New York city on April 16, 17 and 18, 1903, this same idea was expressed by one of the speakers at the society's banquet. Yet one may rather wonder how the combination will turn out, whether the new society will lean more toward the chemist or toward the electrical engineer, or whether it will draw equally from both professions and serve both in equal degree. It is perhaps more by chance than anything else that the society made its headquarters at the Chemists' Club; but a more direct indication is that much of the technical work of the meeting, as also of the previous meeting at Niagara Falls, seemed to belong more to chemistry, at least to its branch of physical chemistry, than to engineering. Curiously enough, too, one of the papers at this meeting was confessedly an appeal by the electrician to the chemist. Still, a fair portion of the papers and discussion dealt directly with practical details of electrolytic work, a field in which a great number of electrical engineers are actively engaged; and, of course, all progress in electrochemical knowledge is a direct advance in the fundamentals of electrical engineering, a relation which is probably in nothing so clear as in the field of reversible cells—storage batteries. One other important service may be mentioned here which the new society can render the electrical engineers: it can relieve them of the greater part of elusive and often illusive speculation on ultra-theoretical questions, such as the electronic hypothesis and the nature of electrical phenomena.

While there was no great argument in this field at the present meeting, an approach toward it was made once or twice when a difference of opinion arose as to what constituted metallic conduction.

The attendance at the meeting exceeded 200 persons; this, together with a good program and fairly animated discussion, keeps up the promise of the society's first year. The social and general side of the meeting also was satisfactory. There were visits to plants on the afternoons of two days, a reception and banquet, and a much-enjoyed "German-American smoker (Kneipe)," as the program puts it, on the last evening of the meeting.

A notable feature of the meeting was the presence of the noted physical chemist, Prof. Walter Nernst, of Göttingen, Germany, who communicated the results of some recent investigations on high-temperature vapor density determinations. This work is of high value since it gives information as to the constitution of matter at very high temperatures, where hitherto our knowledge has been exceedingly limited. Prof. Nernst, who spoke in German, exhibited to the society the iridium vessels with which he carried out his experiments, and which made them possible. An abstract of his address is given further on.

Two special events were a lecture by Mr. Wm. J. Hammer, on "Radium and Other Radio-Active Substances, the Properties and Applications of Selenium, and the Treatment of Disease by Ultra-Violet Rays," which was delivered before the society in joint session, by invitation, with the American Institute of Electrical Engineers, and a demonstration of the Hewitt mercury-vapor converter and the Hewitt mercury-vapor lamp by Messrs. P. H. Thomas and M. von Recklinghausen. The lecture of Mr. Hammer was very fully illustrated by experiments and exhibits, and in spite of its length was followed with great interest, as the investigations and discoveries it described are the work of a few European scientists and most of it is so recent that only reports of it have come to this country. The Hewitt converter, shown in action by Mr. Thomas, has been briefly described in Engineering News. Alternating current was converted to direct current and the latter used to light incandescent lamps and run a motor. The address of Mr. von Recklinghausen, who showed several Hewitt lamp tubes in action, referred especially to the utilization of the high actinic value of this light. It is thought that the lamp may be developed into a valuable aid to the photographer, and that it may be utilized with success for commercial blueprinting, etc. Its actinic value is many times greater than that of the arc lamp, so that a much shorter exposure is required.

It was announced during the meeting that a prize of $250 had been offered by Mr. A. B. Frenzel, of Denver, Colo., for the best research work on the treatment of ores of rare metals. The award of the prize will be in the hands of the directors of the society. Mr. Frenzel not only offers the prize, but also stands ready to furnish the ore for the experimental work, in any reasonable quantity, f. o. b. Denver.

BUSINESS MATTERS.

The meeting was opened by a welcoming address of President McMurtrie of the Chemists' Club, to which brief response was made on behalf of the American Electrochemical Society by President Richards. The report of the secretary, Mr. C. J. Reed, announced a total membership of 512, with 53 foreign members; the members are scattered over 36 states and territories of the United States and 11 foreign countries. The growth of the society is expected to continue, and the suggestion was offered that the society might in the near future find it desirable to establish local branches in various cities, on the plan inaugurated with success by the American Institute of Electrical Engineers during the past year. The treasurer reported a flourishing financial condition.

The annual election of officers resulted in continuing all the present officers for another term. They are: President, J. W. Richards, of Bethlehem, Pa.; Vice-Presidents (to serve until 1905), W. D. Bancroft, of Ithaca, N. Y., C. A. Doremus, of New York city, and W. R. Whitney; Secretary, C. J. Reed, of Philadelphia, Pa.; Treasurer, P. G. Salom, of Philadelphia, Pa.; Managers (to serve until 1906), S. Reber, of Washington, D. C., S. P. Sadtler, of Philadelphia, Pa., and C. O. Mailloux, of New York city.

The Presidential Address was delivered by President Richards at the last session of the meeting. He had as his general theme "Conditions of Progress in Electrochemistry," and analyzed in detail the factors that contribute to progress, placing first in the list the discovery of new facts, and second to this, a clearer understanding of the laws governing the phenomena of the science. In discussing theories, he gave full appreciation to their value in aiding toward a concrete understanding, but pointed out that any theory becomes a danger when it acts as a strait-jacket to a developing science. The matter of cheap power received due attention, as being essential to the advance of electrochemical industry and therefore to the progress of science. One of the developments which he foresees in the next decade is the extended utilization of gas from blast furnaces and coke-ovens, and of gas from producers using low-grade fuel, for the generation of mechanical power. As the best single function of a society like the American Electrochemical Society the speaker named the enlargement of vision and the professional enthusiasm which it brings to the individual members, and this is an important condition of progress.

At the final session, a general vote of thanks was tendered the Chemists' Club and other organizations and individuals who had helped to make the meeting a success. Prof. C. A. Doremus then brought to mind the Fifth Congress of Applied Chemistry which is to be held in Berlin, Germany, in June of this year. According to Mr. H. W. Wiley, who is in charge of the American representation at the congress, this country will probably rank second in the number of those attending. The 10th section of the congress is devoted to electrochemistry, and as some important matters are to be discussed, such as the establishment of electrochemical units, it was urged that all who can of the members of the society attend the sessions of this body.

The meeting closed with some parting words by President McMurtrie of the Chemists' Club. He extended a hearty invitation on the part of the club to all members of the society to visit it at any time. After this, the post-adjournment session, the "Kneipe" already mentioned, continued far into the night.

Technical Proceedings.

The first paper presented before the meeting was "Constant Voltage and Constant Current Separations," by Prof. W. D. Bancroft, of Ithaca, N. Y. It referred to the electrolytic separation of different metals, which is accomplished by virtue of the fact that the metals separate out at different voltages. The ideal method, therefore, is to employ a voltage high enough to precipitate one of the metals but too low to precipitate the other; then if the voltage is kept constant, the separation proceeds and stops itself automatically. As the precipitation progresses and the solution becomes poorer in the one metal, the current flow decreases gradually to a low value. The author says:

> As a matter of fact this method is not used in most of the standard separations, which are rather to be classed as constant current separations, even though the current may not be held absolutely constant. In order to prevent the second metal precipitating as soon as the first is all down, it is essential that hydrogen shall be set free by the current instead of the second metal. The essential feature, therefore, of a constant current separation is that the decomposition voltage for hydrogen in any solution shall lie below the decomposition voltage of one of the two metals. Since most separations were originally made without a voltmeter in circuit, no satisfactory results were obtained until a solution was found which permitted of a constant current separation, and for this reason all except some of the most recent separations are constant-current separations.

In order to supply some missing but much-needed data in this field, the author has determined and here presents in tabular form the order of precipitation of the common metals from various specified solutions. From these lists it may at once be determined whether a certain separation is to be made by the constant current or the constant voltage method. There are some exceptions to this, however, which the author notes and suggests explanations for.

DISCUSSION.—A remark by the author on the precipitation of brass caused some discussion as to whether brass is ever precipitated as such. One or two members reported that they had observed brass to precipitate under certain conditions, in sufficient quantity to permit accurate chemical analysis. Prof. Bancroft held, however, that copper and zinc never come down together as brass, but that in the cases where they do precipitate simultaneously they may form a mixture looking like brass which is, however, composed of separate particles of the two metals, as revealed by the microscope.

A paper by Prof. H. T. Barnes, of Montreal, Canada, on "Experimental Study of Some Electrode Effects," was read in the absence of the author by Prof. Bancroft. In certain potential measurements in electrolysis the results obtained showed considerable irregularity under apparently identical conditions. This was traced down to the presence of air in the electrolyte, and the use of solution freed from air was found to enable concordant results to be secured.

Under the title "The Electrolysis of Water," Prof. J. W. Richards, of Bethlehem, Pa., and Mr. W. S. Landis described the results of a number of experiments. Probably the most interesting of these was suggested by a communication presented at the Niagara Falls meeting of the society by Messrs. C. Hering and C. J. Reed, who

had observed that the decomposition voltage of water decreased under increasing pressure. The present authors attempted to electrolyze water in a closed vessel completely filled with sulphuric acid solution. It was found that the glass containing tube always broke until they employed a thick-walled capillary tube sealed with Canada balsam, with platinum electrodes separated about one millimeter. It was found that no current would flow through this apparatus, even under an applied pressure of three volts. The bursting strength of the tube was probably about 5,000 atmospheres, while the electrolytic action represents a pressure of only about 1,800 atmospheres. The authors also made a number of experiments on voltage and current in electrolyzing water and concluded that at very high resistances between the electrodes the relation between voltage and current flow is the same as in metallic conduction. There was some discussion of the paper, much of which arose from an imperfect understanding of the paper, the latter not having been printed.

In a paper entitled "Experiments with Metallic Diaphragms," Prof. W. D. Bancroft, of Ithaca, N. Y., discussed the case of an electrolytic cell with an interposed metallic diaphragm which does not completely fill the cross section of the cell, and the case where there are two (or more) such diaphragms in series in the cell. He showed that if there is metallic connection between such series diaphragms, a local electrolytic circuit may form which interferes with the action of the cell.

The session of Thursday afternoon (April 16) was opened by Mr. C. J. Reed, of Philadelphia, Pa., with a paper on "The Protective Action of Zinc Chloride on Metallic Iron." The author holds that as zinc chloride solutions contain free ions of chlorine (according to the electrolytic dissociation theory), a piece of iron placed into the solution should be attacked. He found that it was not attacked, but remained perfectly clean even after two years' immersion. He is unable to supply an explanation of the phenomenon. Mr. M. von Recklinghausen then read a paper on "Insulating Materials, a Field for Chemists," which is reprinted in another column of this issue.

In "A Historical Review of the Storage Battery," Mr. H. B. Coho, of New York, recorded the principal steps in the evolution of accumulators. The scientific and technical development of this important form of electrolytic cell may be said to cover the entire period of years from Muschenbroek, 1725, to Edison, 1900, but more properly it begins in 1860, only forty years ago, with Planté, and enters upon a second era in 1880-1885, with Faure and Brush. The author also gave a brief résumé of the rise of the commercial application of storage batteries. In discussion, Prof. Carhart told of a conversation he had with Gaston Planté, in 1881, in which Planté had told him that he had tried applying the active material to lead plates, as a substitute for formed plates, but that he had found them inferior to the latter. Mr. N. S. Keith mentioned that he himself had in 1881 patented a plate not requiring forming.

Mr. E. A. Sperry, of Buffalo, N. Y., read a paper on "The Use of Pyroxyline in Electric Storage Batteries," in connection with which he exhibited some samples of his improved form of pyroxyline (gun cotton) fabric for enveloping storage battery plates. In the operation of accumulators it is found that the positive plate has a much shorter life than the negative. Expansion and contraction tend to crack off parts of the active material, overcharging makes the hardest active material soft, and in case of movable batteries the surface wash of the liquid acts very destructively; this action is restricted to the positive plate, the negative being little affected. On this account even the earliest experimenters with storage batteries, Planté among the number, wrapped the positive plate in a porous envelope; this envelope held the active material in place, which is nine-tenths of the problem of making a successful battery. Pyroxyline has lately been tried as an envelope material, and has been improved in form to the point of commercial practicability. In its present form, as developed by the author, it is made from cheese cloth, carefully freed from water and starch before nitrating; in appearance and feel the pyroxyline is exactly the same as cheese cloth. By using nitro-benzol in the final washing, it is rendered hygroscopic and thereby becomes very safe to handle. The inflammable character of the material was demonstrated repeatedly during the reading of the paper, by the combination of a sample piece, an inquisitive member of the audience and a lighted cigar; but when wet it does not burn. The pyroxyline envelope cannot be used on the negative plate, because of the strong reducing action there. The use of envelopes has advantages in the way of prolonging the life of the plates, reducing the amount of mud collecting in the bottom of the cell and hence reducing the danger of short-circuiting, etc. The author further pointed out that while the envelope must be porous enough to offer a negligible resistance at the four-hour rate of discharge, it may have a high resistance on short-circuit, and thereby protect the cell somewhat in that emergency. There was no discussion on the paper.

In electrolyzing brine to produce caustic soda and free chlorine, a porous diaphragm is required in the cell. It is found that in operating such a cell the relative concentrations on the two sides of the diaphragms gradually change from those required by theory. Mr. W. H. Walker, of Boston, Mass., gave an explanation of this, in a paper on "The Concentration Changes in the Electrolysis of Brine," basing his argument on the migration of ions. The same action had previously been explained by C. P. Townsend, of Washington, D. C., as the effect of osmotic pressure, and he now maintained his view of the phenomenon against Mr. Walker. It developed, however, that the form of cell assumed by the latter was substantially different from Mr. Townsend's cell, although the latter would not describe the exact arrangement which he used, because of the patent situation. Mr. P. Fireman also took part in the discussion.

An interesting paper, not previously announced as being part of the program, was presented by Prof. H. S. Carhart, of Ann Arbor, Mich., and dealt with the subject "A Thermoelectromotive Force without Difference of Temperature." When current flows with an electromotive force at a certain point, energy is absorbed by the circuit at that point, while when it flows against an electromotive force the circuit gives off energy at that point. Thus, when current is sent across a thermoelectric junction in a direction opposite to the pressure normally produced at that junction, the junction becomes hot, or gives off heat (Peltier effect). Duddell has found a thermoelectric pressure from carbon vapor to carbon, and hence in an arc lamp heat is liberated at the positive carbon (where the current is sent against this pressure) and absorbed at the negative carbon (where the current goes with this pressure). In a metallic circuit with two or more junctions, when the circuit is all at the same temperature the integrated thermoelectromotive force around the circuit is zero; but if part of a circuit is formed by an electrolyte this is not necessarily true. The author very prettily illustrated this by developing the complete Carnot cycle (of four periods) for a concentration cell.

In discussion, Prof. J. W. Richards questioned the statement that there is no thermoelectromotive force between the solutions on opposite sides of the diaphragm, saying that he saw no reason why this should be true. Prof. Carhart answered by stating that he had attempted to measure this pressure in a Daniell cell, but had found that if existent it was too small to observe.

A paper collating numerous practical observations on electrolytic corrosion was next read by Mr. A. A. Knudson, of New York city. Its most interesting part described potential and current measurements made in New York city, and showing strong earth currents from the return of the Brooklyn trolley system. The effects of these earth currents were illustrated by several photographic views. Discussing Mr. Knudson's paper, Mr. C. Hering claimed that false deductions were often made from potential difference measurements; when a high p. d. existed between two points, it was often concluded that a strong current flowed between them, whereas a low p. d. was taken to indicate a weak current. As a matter of fact the relations might be just the reverse, depending entirely upon the resistance between the points. For the case where it is desired to measure the current flowing between two points (of a water pipe or other conductor), Mr. Hering suggested the following method: Measure the voltage between the points, then connect an ammeter between them and measure the current in the ammeter and the voltage now remaining between the points. Then the current flowing through the pipe is found from the formula

$$I = \frac{e_1 \, i}{e_1 - e_2}.$$

A further suggestion made by Mr. Hering was to prevent the corrosion of iron pipes by connecting a block of zinc to the pipe at intervals, the zinc being buried in the ground near the pipe; then the zinc "sucks" the current out of the pipe, i. e., much current leaves the pipe by way of the zinc which would otherwise leave by way of the wall of the pipe directly. When the zinc is corroded it can easily be renewed. Mr. N. S. Keith did not seem to expect much protection for pipes from this scheme; on the other hand he doubted whether corrosion need be expected in most cases where stray currents flow through pipes. Mr. Knudson corrected some remarks of Mr. Hering's by saying that conclusions as to electrolysis are not based on the amount of current flowing; the measurements of potential difference are the material from which opinions and conclusions are formed, and even these measurements are only taken as indicating conclusions rather than dictating them. His measurements of current flow in pipes by the p. d. method, as recorded in the paper, had been checked by direct tests and found to be quite close. On the suggestion being made that water and gas pipes might be covered with cement in order to protect them from electrolytic corrosion, Mr. Knudson said that the cost would render this an impracticable method even if effective. Mr. J. W. Richards told a story of an aluminum yacht tied to a steel wharf by a steel wire hawser, and a sailor who got a stiff shock on touching the cable; Mr. C. J. Reed at once cast doubt on the truth of this story, because of the voltage from such a combination being far too low to give a shock. A copper-bottom vessel tied to a steel-bottom vessel by a steel cable would form a galvanic couple and current will flow across and may cause corrosion. The use of zinc in boilers and in marine condensers to prevent corrosion was also mentioned, as being an example of electrolytic corrosion of one metal used to protect another metal from corrosion. Mr. C. Hering suggested that theoretically aluminum should be better than zinc for this purpose, but that possibly the tendency for an oxide coating to form on that metal might interfere with the action. Mr. A. E. Breneman stated that copper kettles used to dissolve tin in hot strong hydrochloric acid last for a long time, the tin protecting the copper from the acid.

At the following session, on Friday morning (April 17) Mr. N. S. Keith read a paper entitled "Notes on the Composition of Electroplating Solutions," which discussed the determining conditions and the difficulties encountered in electroplating and metal refining. Electrogilding received an extended treatment, and silver plating likewise. Some notes on lead refining by the sodium acetate method concluded the paper. There was some discussion on the paper mainly by Messrs. H. E. Heath, C. O. Mailloux and A. H. Eddy. Of special interest was a statement by Mr. Heath that a unipolar generator built eight years ago by the Eddy Electric Co., for electroplating has been used ever since; the voltage of the machine is very uniform, against the fluctuating voltage from an ordinary dynamo, and the machine gives better results than the latter in plating work.

Following Mr. Keith, a rather related paper was read by Mr. Titus Ulke, of Sault Ste. Marie, Ontario, on the subject "Modern Electrolytic Copper Refining." Mr. Ulke introduced his paper by deploring the practice in this country of

making a trade secret of everything pertaining to electrolytic copper work (and indeed all other industrial electrochemical work); he showed that this was not only unfortunate for the electrochemical profession, but that it was against the best interests of the refiners themselves. He then outlined the general method of electrolytic copper refining, and gave all the leading numerical data. The progress made in this branch of industry during the last ten years was traced by the author to a general improvement in operating methods. The handling of the material throughout is now done mechanically, by cranes, conveyors, and the like, higher current densities are employed in the tanks, and these with many other similar improvements specified by the author have coöperated in the advance. The author placed the world's production of electrolytic copper at 322,000 tons annually, worth about $300 per ton, and the United States produces 86% of this amount; a large value in byproducts is also recovered. For further details on the subject the author referred to his book, of the same title as the paper, shortly to be issued by the publishers (Wiley & Son).

THE DETERMINATION OF VAPOR DENSITIES IN THE ELECTRIC FURNACE.

By Prof. Walter Nernst, Göttingen, Germany.

It is only the most recent time, hardly more than the last decade, which has given to physicists and chemists the possibility of working at exceedingly low and exceedingly high temperatures. Experimental knowledge of the highest value has been the fruit of this possibility as utilized in many brilliant investigations. Prof. Nernst has lately made an important addition to this knowledge by studying the constitution of substances at temperatures of about 2,000° C. But the credit for the contribution does not all belong to Prof. Nernst, for his work was rendered possible only by an excellent achievement on the part of the famous instrument-maker, Heraeus, of Hanau.

To make the desired determinations of vapor densities at high temperatures, Meyer's method suggested itself as the most suitable. This method involves the use of a small bulb-tube, in which the vapor is contained and measured. But platinum or porcelain vessels reach their limit at about 1,800° C., and for two years past Prof. Nernst has been searching for a suitable material for this bulb. The metal iridium has a fusing point some 500° C. higher than that of platinum; it has the disadvantage, however, that it is very brittle at ordinary temperatures. Heraeus has for some time been working on the problem of making iridium vessels, with increasing success until quite recently he constructed a small Meyer bulb with attached capillary, entirely of iridium. The difficulty of the achievement will be appreciated from the statement that the material had to be forged at a white incandescence.

With this bulb Prof. Nernst was able to carry out his determinations. To secure the high temperature, an electric furnace of the ordinary type might be used, but an iridium resistance muffle which Heraeus also succeeded in making supplied a far better means of heating. This muffle was a tube about ¾-in. in diameter by 8 ins. long, with a wide flange at each end; the tube and flanges were of iridium. Copper heads placed over the flanges conducted the current to the tube, alternating current at 2 to 3 volts being used. A uniform high temperature was thus obtained within the muffle. The bulb-tube being placed in the muffle, with its stem projecting through one head, the substance in the bulb was vaporized and the volume of the vapor then measured by the displacement of a mercury globule in a tube connected to the stem. To determine the temperature of the bulb a photometric method was used, observing on the bottom of the bulb through a hole in the copper head of the muffle; the temperatures were obtained probably within 10-20°, an accuracy which is expected to be considerably exceeded after careful standardization.

The substances investigated up to the present have been the chlorides of sodium and potassium, metallic mercury, and water; the quantities used varied from 0.2 mg. to 1.7 mg., but the calculated values show that a great accuracy was nevertheless obtained. The vapor densities and molecular weights were calculated from the experiments, and these indicated the degree of dissociation.

DISCUSSION.—Prof. J. W. Richards expressed the belief that this work gave a means of completing our at present fragmentary knowledge of the thermal actions in the electric furnace, a very important matter for both theory and practice of electric furnace work. Prof. W. D. Bancroft remarked upon the great accuracy of Prof. Nernst's results, obtained with such minute quantities of material; only rarely do determinations at ordinary temperatures, made on much larger quantities, yield such results. This is a high compliment to Prof. Nernst's skill as an experimenter. Mr. L. Baekeland asked whether determinations of the vapor density of cadmium could be made in this apparatus, or whether the cadmium vapor would destroy the bulb by acting on the iridium. Prof. Nernst was of the opinion that at these exceedingly high temperatures cadmium would probably not form an alloy with the iridium; he expects in the near future to extend his investigations by using inert atmospheres in the bulb, so that he may determine zinc, cadmium, potassium and sodium.

A paper entitled "Notes on Electrical Endosmose" was next read by Prof. W. D. Bancroft. This was largely of theoretical interest; it treated of the rate of passage of solutions through porous diaphragms under the influence of an electric current, and described a few experiments on this. It was concluded that for certain processes of electrolysis it was essential that the rate of endosmose should not exceed a certain amount; but there are also reasons why the rate should not be too small. Negative endosmose (against the current) was considered as to its possibility, as was also the question of whether electrolytes always remain unchanged in passing through diaphragms. The author thought that there was evidence of a change in some cases.

A paper entitled "Ions and Electrons," by Mr. L. A. Parsons, of Baltimore, Md., gave a summary of the building-up of the dissociation theory and later the electronic hypothesis. It received no discussion. Under the title "Uniformity of Electrochemical Equivalents" Mr. C. Hering, of Philadelphia, Pa., remarked upon the present diversity in the accepted values of electrochemical equivalents of different substances, and advocated the adoption, as temporary standard, of a set of equivalents formed by combining the values of atomic weights selected and adopted by the American Chemical Society, with the value for the electrochemical equivalent of silver which has been adopted internationally and is legal in this country. The value for hydrogen on this basis is 0.010441 mg. per coulomb. The author expressed the opinion that in the future the atomic weights might possibly be derived from the electrochemical equivalents and the value for ionic charge. The discussion showed some differences of opinion as to the advisability of the proposed step. Prof. W. D. Bancroft pointed out that according to the best recent determinations the legal value for the electrochemical equivalent of silver is incorrect (about 0.04% too high), so that the entire set of values calculated from it would be in error. Prof. J. W. Richards took the ground that it was better to get along without a legal set of values, just as no chemist wants to legalize the relation between the atomic weights of hydrogen and oxygen.

A paper by Prof. W. D. Bancroft, of Ithaca, N. Y., on "The Electromotive Force of Alloys" recounted some experiments which showed that uniform sets of values for the electromotive force of any given alloy could only be obtained if the alloy is in chemical equilibrium. A splitting-up of the component eutectics occurred rather easily, and vitiated the results. Thus, in testing bronze it was necessary to anneal it after casting in order to get concordant electromotive force values.

Prof. C. F. Burgess and Mr. C. Hambuechen, of Madison, Wis., presented a paper entitled "The Electrolytic Production of Metallic Compounds." After stating that the literature of Applied Electrochemistry is often quite unreliable, and that in many cases the statements of this literature can not yet be realized in practice, the authors discuss the manufacture of whitelead, which is still produced chemically, after many failures at attempted electrolytic manufacture. They describe in detail the difficulties of the latter (by electrolyzing lead against sodium nitrate to form caustic soda and lead nitrate, mixing the products to form lead hydroxide and finally precipitating the latter with carbon dioxide) and describe the apparatus used by them to overcome these difficulties.

The session of Saturday morning (April 18) was opened by a paper on "The Electrodeposition of Metals Upon a Rotating Cathode," by Mr. J. G. Zimmerman, of Madison, Wis. It was found from experiments that smoother and better deposits could be obtained and higher current densities used when the cathode was rotated than when it was stationary. The author attributes this to the frictional effect of the solution, which acts to smooth down any irregularities which may tend to appear. In discussion, Mr. C. Hering thought that exactly the same results would be obtained by circulating the electrolyte, which is usually a much simpler arrangement mechanically than the rotating cathode; it has the advantage, moreover, that the anode is affected the same as the cathode, which is important in view of the author's statement that the anode did not stand such high current densities as the rotating cathode. Mr. Hering considered the author's explanation a wrong one, and explained the results by the exhaustion of the metal in a thin layer over the cathode surface, which causes liberated hydrogen to interfere with the deposition (in case of the stationary cathode). Mr. C. J. Reed agreed with these views, holding that neither the friction of the liquid nor centrifugal effect has anything to do with the result. Circulation of liquid at the anode is just as important as at the cathode, however, he thought that with some forms of electrode the circulation of the liquid might not be the simpler arrangement, mechanically. Mr. A. H. Eddy called attention to the necessity of increasing the speed of rotation in proportion to the current density. Prof. W. D. Bancroft claimed that when the liquid is circulated it is more difficult to constantly renew the surface layer against the cathode than when the cathode is rotated; at any rate he had been able in the latter case easily to use current densities which could not be used at all when the liquid merely was circulated. Mr. H. E. Heath spoke of plating some spheres, which were rotated in the bath; they showed a spiral line on which the plating was thinner, the spiral running opposite to the rotation. Prof. C. F. Burgess maintained the friction effect explanation, stating that at very low current densities, when the surface film of the electrolyte renews fast enough for a stationary electrode, a polished surface was obtained by rotating the cathode where a matt surface was produced without the rotation. He also pointed out that the heating of the electrolyte is one of the limits to current density. Mr. W. T. Taggart mentioned some experiments by Mr. E. F. Smith at the University of Pennsylvania, in which he rotated the anode and was thereby enabled to obtain some unusually rapid plating.

Mr. A. B. Marvin, of Washington, D. C., described some interesting experiments in a paper on "Electrolytic Conduction Without Electrodes." The question is, can a current flow in a closed circuit of solution, where there are no electrodes by which the current may enter or leave the circuit. Such a current, if it can exist, would of course have to be produced by induction from the outside, and with this idea the author tried unipolar induction, induction from a rotating field, and transformer induction. A rotative effect was obtained in the second experiment which the author explains by local currents set up in the body of the electrolyte. But a more positive effect was obtained by transformer induction, using a generating transformer and a test transformer; the secondary of the first and the primary of the second was formed by a single circuit of electrolyte contained in a coiled glass tube. A telephone receiver in the secondary of the test transformer gave certain buzzing sounds which were taken to indicate an induced current in the liquid.

Considerable discussion followed this paper. Mr. Hering considered this the first demonstration of electrolytic conduction without electrodes, but Prof. Bancroft stated that Boys had demonstrated this in England twenty years ago. It was regretted that the experiment of direct-current induction (by unipolar dynamo) did not succeed. Prof. N. M. Hopkins, of Washington, D. C., described an apparatus which he had used; it was of the transformer type, the test coil of the electrolyte, instead of having a testing secondary was provided with a sheet-iron core and the whole put in a calorimeter, to measure the hysteresis heating in the sheet iron. A slight rise of temperature was detected and was taken to indicate a current in the electrolyte. However, the exciting coil of the electrolyte had a bar core on which was a primary winding, and though this was one meter distant from the test coil, Professor Burgess thought that stray field effects might have caused the observed heating. This was also the opinion of Prof. Carhart, especially because the exciting coil had an open magnetic circuit which necessarily produced a large stray field. A question was now raised by Prof. Richards, who advanced the opinion that from the author's experiment the conduction in the electrolyte would appear to be the same as metallic conduction. Prof. Richards subsequently defined metallic conduction to be that in which no electrolysis takes place. This view was strongly combatted, mainly by Mr. Hering and Prof. Carhart. The former considered that a given portion of the electrolyte "doesn't know" whether or not there are electrodes in another portion of the liquid. Prof. Carhart went further than this and stated that attempts had been made and had failed to show a movement of particles in metallic conduction, so that, even though conduction in an electrolye be unaccompanied by dissociation, the character of the conduction might yet be fundamentally different from that in a metallic conductor. Mr. C. J. Reed considered the question "what makes the ions move" a fair one. The explanation was offered that the alternating attraction and repulsion of the magnetic field upon the separate ions causes a surging of these ions which is equivalent to current flow. This explanation would not hold, however, in case of a direct current.

Messrs. H. E. Patten and W. R. Mott, of Madison, Wis., presented a paper entitled "Potentials of Zinc in Aqueous Solutions," which contained the results of a great number of experiments on the variation of potential with varying current rate, for many different electrolytes. Curves of the results were shown. Mr. W. M. Johnson, of Hartford, Conn., presented a paper entitled "Notes on the Electrodeposition of Nickel," which gave a few observations on the curling of nickel cathodes.

The final paper of the meeting was read by Mr. Barry McNutt, of Bethlehem, Pa. It described "A Laboratory Electric Furnace," consisting of an upper electrode, a graphite crucible serving at the same time as lower electrode, and a base which might be used for different sizes of crucible. This base was made of a cylindrical bundle of electric light carbons, the bundle being held in a sheet-iron jacket. The stranded copper conductor was fanned out and entered the bottom of the bundle, separate wires passing up the interstices between the carbons. The top of the bundle had a raised outer rim, and the depression was filled with crushed carbon, the same material being packed into the spaces between the carbons. Any size of crucible could be used by simply settling it into the crushed carbon on top of the base, the upper electrode being then lowered into the crucible.

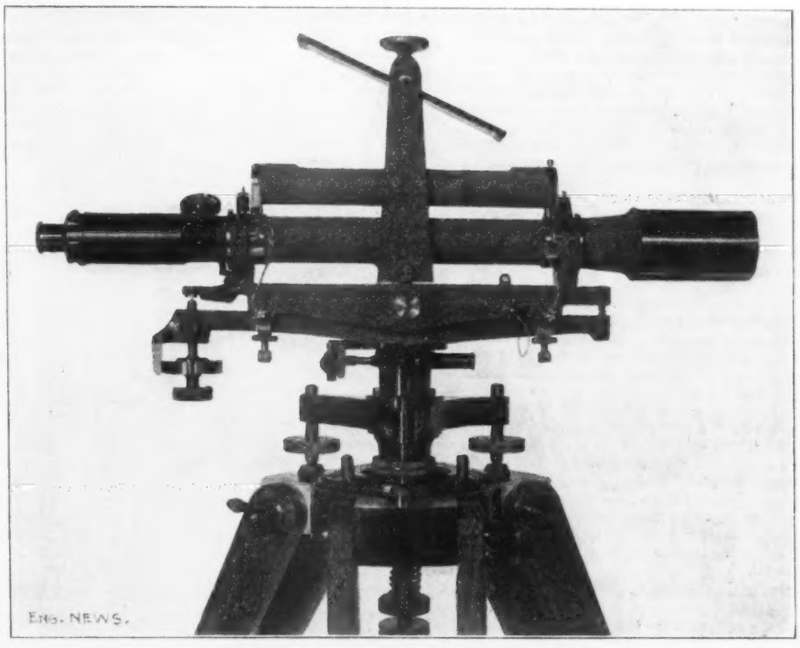
There were, in addition, several papers which were read by title only, and which will be printed in the "Transactions" of the society. Among these are "The Influence of Some Impurities in Salt Upon the Yield of Soda by the Amalgam Process," by Mr. J. W. Walker; "The Formation of Nitric Acid Under Electric Influences," by Mr. C. W. Volney; "Free Ions in Electrolytic Solutions," by Mr. W. R. Whitney. One or two of the papers originally announced in the program of the meeting were withdrawn or otherwise failed of presentation.

A NEW LEVEL FOR PRECISE LEVELING.

The accompanying photogravure, Fig. 1, shows a new form of level originally designed by Prof. T. C. Mendenhall, late Superintendent of the U. S. Coast and Geodetic Survey and now President of Worcester Polytechnic Institute. The design, however, has been somewhat modified by the makers, F. E. Brandis, Sons & Co., 814 Gates Ave., Brooklyn, N. Y.

The principal departure from the form adopted by the designer was to omit the cradle part of the instrument, thereby eliminating errors caused by unequal expansion and contraction. In place of this cradle was substituted a horizontal spindle, made of steel, from which the upper part of the instrument receives its vertical motion. This spindle is fitted with the greatest of care; its entire length is 3¾ ins. and the friction necessary can be regulated by means of a steel nut at its end. In order to save the instrument from injury by a sudden jar or blow, the moveable part carrying the wyes has a steel screw and jam nut on each end which can be regulated so as to allow the projecting blocks on the lower, or stationary bar just sufficient friction to move truly vertical without causing any friction on the main spindle, thus making the bar almost rigid in its entire length. The whole upper part is so poised that it requires only a very light spring on the opposite end of the screw to cause a gentle depression, leaving hardly any work to be done by the micrometer screw proper. The usual locking device is used, consisting of two screws and jam nuts on the bottom of the bar, as well as a further locking pin, which holds both bars together when the instrument is not in use.

The vertical axis is made of steel, but the screw holding the instrument to the tripod is not in connection with the center proper. It is made of a separate piece. This prevents all possible strain upon the vertical axis. All points of contact as well as the telescope collars are made of hard steel, to prevent possible wear. The striding level has on its lower ends a pair of opposite screws and check nuts, which are released pending the lateral adjustment of the level. When adjustment is made, they are brought back to their position allowing just sufficient motion to insure contact with the collars. The object glass has an aperture of 1¾ ins. and has two Steinheil eyepieces which gave magnifying power of 40 and 50 diameters. There is a mirror over the bubble tube, as shown, by aid of which the bubble can be centered without the instrument man's moving from the position taken in sighting.



A NEW PRECISE LEVEL.
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INSULATING MATERIALS; A FIELD FOR THE CHEMIST.*

By Max von Recklinghausen.

The great hopes we had at the beginning of the last decade as to the future of the electrochemical industry in its purest form, that is, as technical electrolysis, were not all realized. The main advance during this time in the electrical manufacture of chemical and similar products has been due not to the use of current as an electrolyser, but to the application of the electric current as a source of heat for chemical and physical reactions which heretofore, if known at all, could be carried out only on a laboratory scale.

The manufacturing chemist is the one who has gained enormously during this time, because the electrical engineer has put at his disposal heat sources of an undreamt-of magnitude. The advance in electrical engineering has enabled the technical chemist to economically use high temperature reactions for making products and compounds which until then were scarcely obtainable in the laboratory. The electrochemist is therefore under the greatest obligations to the electrical industry. It is only fair that he should show his gratitude by helping the electrical engineer out of his troubles in a field where his chemical research is of vital importance; I mean the field of electrical insulating materials.

Up to now the electrical engineer in most cases has been left to himself to find the best insulating material for his particular purpose. All he could do was to pick out the most promising ones amongst those offered to him by the trade. But he is far from having the ideal materials for the different types of insulation, especially for high-tension work, which is greatly handicapped by the lack of suitable insulating materials.

This is therefore the time when the chemist should step in and use his knowledge and ability for producing for the electrical engineer insulating materials that are better and more satisfactory than those obtainable to-day. While there are doubtless many chemists, especially among the makers of varnishes and oils, etc., who are on the outlook in this important field, among chemists generally there is but little interest in these matters and generally small appreciation of the enormous value that chemical work in this field would have for the advance of the electrical industry.

One can safely say that one of the main reasons why the electrical engineer got little help in this field from the chemist lies in the fact that the chemist does not appreciate the different wants of the electrical engineer. It happens over and again that chemists offer materials for insulation which may have one good property, but lack others, which may, for instance, have enormous resistance to passage of current, but be so highly inflammable or so low melting as to be utterly useless for the purpose intended.

In the following I shall try to give a general idea of the desirable and the undesirable qualities of the promi-

*A paper read at the New York meeting of the American Electrochemical Society, April 16-18, 1903.

nent insulating materials used nowadays, and shall furthermore try to point out where chemical research would be particularly important. To start with, we have to classify the properties under which the different insulating materials have to be considered, as follows:

1. Electrical Properties.—(a) Insulation resistance or conductivity, expressed in ohms per cubic centimeter; (b) disruptive or dielectric strength, measured by the potential necessary to puncture the material; (c) dielectric constant, or specific inductive capacity, measured by the capacity in microfarads of a condenser having the particular material as dielectric separating the metal plates. This last named property is less important than the two preceding.

2. Mechanical Properties.—(a) Strength and workability (in case of solids); or, (b) flexibility and workability (in case of semi-solids); or (c) viscosity (in case of liquids).

3. Chemical Properties.—(a) Combustibility; (b) property of resisting the influence of moisture (hygroscopic quality), air, oil, acids, etc.

The factors which may considerably influence the properties of the insulating materials during use are the following:

1. Rise of Temperature (sometimes going so far as to melt or char organic materials).—It may be due to: (a) Current passing in virtue of the insulating, with not enough chance to radiate the heat generated; (b) heat conducted into the insulating material from outside sources, such as the metallic conductor; (c) dielectric hysteresis, due to very frequent application and withdrawal of high electrical stress, such as high voltage alternating current with not enough chance to radiate the heat generated.

2. Mechanical Stress, resulting in change of shape or breaking.

3. Chemical Action, as of water, oil, ozone, nitrous fumes (which may be generated by brush discharges nearby), or gases and fumes developed by factory processes in the neighborhood of the electrical apparatus.

Desirable qualities are, mainly, good insulation resistance, high disruptive strength and fair mechanical properties, especially workability. Undesirable are, mainly, combustibility and changes in the electrical and mechanical properties with rise of temperature or with age, and, of course, high price.

To chemically classify the insulating materials, it is practical to consider them under the headings of:

I. Organic materials, liquid and solid. II. Mixtures of organic and inorganic materials. III. Inorganic materials.

I (a). LIQUID ORGANIC MATERIALS.—These comprise the materials used, mainly, for transformer insulating and cooling, for condensers, and more recently for circuit breakers. Such liquid insulators are the different oils and other liquid organic compounds.

Most properties of the oils as used now are desirable. The worst feature inherent to them is their combustibility. The flash test and the viscosity test (and influence of long-continued use on the same) give a good idea of the usefulness of an oil for the purposes mentioned above. In the case of circuit breakers, as well as of transformers, where accidental high potential may have arced through the oil, the broken down oil insulation should soon be repaired and the oil should come back to its original insulating power; at the same time it would be good that such oil does not develop too much of low-flash products which bring with them the danger of fire. In circuit-breaker work some oils will break the arc off very sharply with corresponding back effect on inductance in the line, others will be slower in their action and may thus be more useful for such purposes. Naturally one has to study the effect of the oils on the different materials they come in contact with. Fatty acids seem to be undesirable in such respects, because they are apt to react with copper.

To do away with the worst feature of oils, their combustibility, it has been proposed to use halogen carbon compounds instead of hydrocarbon compounds. It is distinctly worth investigating whether the products resulting from such liquids when the discharge goes through would be of too bad an effect on the apparatus. For instance, tetra-chloride of carbon would probably break up into carbon and free chlorine, and the latter would very likely injure the metal.

I (b). ORGANIC COMPOUNDS USED AS SOLIDS of more or less plastic state.—Typical representatives of this long line are the different varnishes, lacquers, drying oils, rubber, compounds made from blood, glue, all the different cellulose materials, such as for textile fabrics, wood and mixtures of the different materials belonging to this group. It will be rather hard work to make material advance in this field by further research, as the makers of these materials are on the outlook for improvements for some time.

I want to point out some of the disadvantages of the materials used nowadays. Many of them lose their mechanical strength and their insulating power and dielectric strength by age and by short or long duration of high temperature and high electric stress. All of them are more or less inflammable. Here is probably the point where thorough chemical research could find its field. The pure cellulose compounds are probably very good in every regard, especially because they seem to be less affected by heat and less inflammable than the other materials of this group, but up to now, they are fairly difficult to get into the desired dense mechanical shape. Nitro-cellulose and other celluloid compounds are ideal in this way, but of course are out of the question on account of their combustibility. New artificial masses, such as Viscose, cellulose made out of cellulose solution in acids, metal salts, etc., and similar products may very well be worth experimenting with because they are free from nitro-groups and, therefore, are probably little affected by heat. Also glue and gelatine compounds made insoluble by different methods ought to be examined for their usefulness as insulators, and if necessary chemically modified so as to compete successfully in properties and price with materials used now.

One point is important for dynamo and especially transformer insulation, i. e., that the oil used should not have a dissolving or other injurious effect on the insulating material. Furthermore the insulation should not be affected by moisture, which often in large amounts covers cold apparatus brought into warm rooms. Complaints are heard of attack of some varnishes on wires, particularly thin wires. For such purposes it may be good to prevent direct contact of the varnish and the metal by an intermediate coating.

Attempts are being made lately to produce asphalt compounds, which seem to have many excellent properties; still it will be fairly hard to find materials electrically and mechanically desirable but unaffected by oil and water. I scarcely need mention the old problem of finding a replacement of the expensive gutta percha.

II. MIXTURES OF ORGANIC AND INORGANIC MATERIALS.—Typical representatives of this group are materials made of asbestos or mica with varnish, rubber or paper, or similar materials out of the group mentioned before.

The asbestos compounds, as a rule, lack high insulating power, also mechanical strength; the mica papers lack great flexibility and homogeneity.

III. INORGANIC MATERIALS.—The representative materials of this group are slate, marble, asbestos, porcelain and glass. They are, of course, practically unaffected by heat, but lack entirely flexibility and are furthermore fairly expensive to form into the desired shapes. Better in the latter regard, but not so good insulators, are cement-like mixtures made out of water glass and asbestos, or similar materials. Progress in this field may be expected in the line of the castable cements, although up to now they seem to be too hygroscopic.

That even the mineral insulators become conductors at high temperatures has been found out by people working on the Nernst lamp, where after finding a good conductor at high temperature for the glower part, they had great trouble to find a good insulator, at high temperatures, for the heater part.

The main objection to marble for switchboard work is the great expense. Anything to replace marble would be of greatest importance. It should of course not be hygroscopic at all. Some time ago this was found to be important for high-tension line insulators, so that the makers were careful to make insulators absolutely non-hygroscopic by choosing glass free from alkali. Still the beneficial effect of this is to a certain extent overrated, as the heat developed by the leakage current is enough to remove the water which may condense on the insulator.

A tremendous step forward for the electrical engineer would be an insulating material of the flexibility of asbestos and the ideally high insulating and dielectric strength of mica.

MEASURING THE POWER REQUIRED FOR SHEET ROLLING MILLS.

By H. G. Manning,* M. Am. Soc. M. E.

In the writer's experience he has found that the common steam engine indicator, by itself, gives only a slight clue to the average power developed by a rolling mill engine, when sheets are being rolled of comparatively short lengths. He has, therefore, found it very convenient to use the power chart shown in the accompanying figure.

In the tests which the writer has made every working day, in order to know exactly the running conditions of the steam power portion of the Jessop Steel Co. plant, it is necessary to know precisely what the average indicated power is during a certain time each day. This time is taken when a number of slabs are being rolled into sheets of uniform size, the work covering a period of 15 to 20 minutes. From the time a slab enters the rolls until the sheet is finished the indicator pencil is held to the drum and at each pass steam is reversed in the indicator from one end of the engine cylinder to the other. It will be found, as would be expected, that the point of cut-off of the engine varies with every revolution; but a practiced eye can pick out the expansion curve for each pass. In the meantime an assistant stands near the rolls with a stop watch graduated to fifths of a second and rapidly jots down the seconds the slab is in the rolls, the click of entering and leaving being plainly heard.

The interval of time in seconds while the piece is on the back side of the rolls until it enters from the front side again is also accurately noted. We thus have a continuous record of the power developed, as follows:

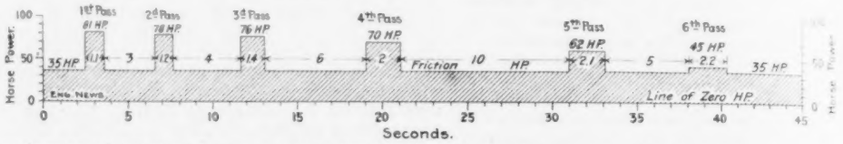

DIAGRAM SHOWING POWER CONSUMPTION IN ROLLING STEEL SHEET FOR 6-FT. CROSS-CUT SAW, 13 AND 15-GAGE, AT THE WORKS OF THE JESSOP STEEL CO., WASHINGTON, PA.

Starting from the time the new slab enters the rolls for the first pass we have, as shown by the chart, a horse power of 81 for 1.1 seconds, then an interval of friction load for 3 seconds. Next the power used in the second pass is 78 for 1.2 seconds, and again a friction load of 4 seconds, and so on until the sheet is rolled. We now have in tabulated form, for one sheet completely rolled, the horse power seconds as follows:

1st pass	81 HP.	for	1.1 secs.	89.1 HP.-secs.
Friction	35 "	"	3. "	105. "
2d pass	78 "	"	1.2 "	93.6 "
Friction	35 "	"	4. "	140. "
3d pass	76 "	"	1.4 "	106.4 "
Friction	35 "	"	6. "	210. "
4th pass	70 "	"	2. "	140. "
Friction	35 "	"	1. "	350. "
5th pass	62 "	"	2.1 "	130.2 "
Friction	35 "	"	5. "	175. "
6th pass	45 "	"	2.2 "	90. "
Total	.....		29.0 secs.	1,629.3 HP.-secs.

$$\frac{1,629.3}{29} = 56.2 = \text{average HP. for 29 seconds.}$$

These observations are continued for fifteen or twenty slabs, and in the meantime, by means of the surface condenser and open heater, an assistant is taking a reading of the actual quantity of water passing through the engines during the above period. This reading is taken by the following method, which has been used for a number of years by the writer.

On the body of the heater is a vertical water glass, on which are two marks, A and B. Before making the test the weight of water at the temperature of the hot well contained in the heater between these two marks is obtained by drawing off and weighing.

Just before making the test all heating steam is shut off from the heater, and no water enters excepting that coming direct from the engine through condenser and air pump, which pumps directly into the heater without intervening hot well. When the test is started, water is drained from the heater below the lower mark "B" on the gage. After the draining valve is closed, the air pump immediately raises the water in the glass, and the instant the level reaches "B" the time is noted. The air pump continues to raise the water in the heater until the test is finished, when the assistant is signaled that the test is completed, and he notes the height of water in the glass above "B." As the heater has already been calibrated, the pounds of water used by the engine during the test is correctly known and the method is accurate when accurately performed.

A test of this sort, occupying fifteen or twenty minutes in morning and afternoon, keeps everybody interested in their work. The power house employes are spurred to do their best, and the company knows every day precisely what its engines are using in pounds of water per HP. per hour.

*Mechanical Engineer, Jessop Steel Co., Washington, Pa.

A CASE WHERE SUPERSTRUCTURE WAS BETTER THAN SUBSTRUCTURE.

On April 15 two spans of the Grand Trunk Railway bridge over the Grand River at Grand Rapids, Mich., fell, owing to the failure of a supporting pier. The accompanying engravings are reproduced from photographs taken just after the wreck.

The bridge is composed of five spans of 100-ft. plate-girders, with shorter approach spans at each end. The girders are 10 ft. deep and spaced 9 ft. apart. The piers are open timber cribs resting on piles and filled with stone to the ordinary water level about 10 ft. below the bottom of the girders. We are informed that the timber appears to have suffered considerable decay above the water level. The bridge is said to have been erected about 20 years ago.

FIG. 1. FAILURE OF A CRIB PIER UNDER A PLATE-GIRDER BRIDGE ON THE GRAND TRUNK RY. AT GRAND RAPIDS, MICH.

At the time of the failure, the water in the river was very high. A yard engine was moving a train of a dozen cars over the structure, two of them loaded 50-ton coal cars, when the pier slowly crushed under the load and the structure settled to the position shown, without derailing the cars. Extra motive power was brought and the cars were hauled off the fallen span. The other piers still standing are said to show as much decay as the one that failed. The only reason assigned for the failure to make a more permanent substructure when the plate girders were erected is the desire to save expense. It may be noted that the line on which the bridge is located is the old Detroit, Grand Haven & Milwaukee Ry., now part of the Grand Trunk system.

A DEFENSE OF THE HIGH PRICES FOR STREET LIGHTING IN NEW YORK, AND A REPLY THERETO.

The recent report advocating a municipal street lighting plant for New York city, made by Mr. Robert Grier Monroe, Commissioner of Water Supply, Gas, and Electricity, and printed nearly in full in our issue of March 19, 1903, has brought out two other reports, or papers. The first of these is a statement by Mr. John M. Bowers, on behalf of the Consolidated Gas Co., at a legislative hearing at Albany, on April 7, which was published as a three to four-column advertisement in the New York city papers of April 8. To this statement a reply, addressed to Mayor Low, was made by Mr. Monroe on April 15.

Mr. Bowers states that the unit cost for ordinary gas lighting in Manhattan borough is less than in most of the other cities included in Mr. Monroe's tables, and attributes the high prices for the same service in the Bronx to the small private consumption there, alleging that the company has some 40 miles of mains on which there is practically no private consumption, and citing a mile or less of expensive pipe laying on which the revenue from public lighting is not enough to pay 4% interest on the cost of the mains.

In replying to this portion of Mr. Bowers' statement Mr. Monroe first says:

> The Consolidated Gas Co. bids for 1903 $17.50 per lamp per year, agreeing to furnish 22-c. p. gas through a burner consuming 3 cu. ft. per hour at a pressure not less than 1 in. In the year 1882 the Metropolitan Gas Light Co. (since absorbed by the Consolidated Gas Co.) bid $17.50 per lamp per year, agreeing to furnish gas from 20 to 23 c. p. through a burner consuming 3 cu. ft. an hour at a pressure of not less than 1 in. In the year 1882 the lowest price charged to private consumers in the Borough of Manhattan was $2.25 per 1,000 cu. ft. During the last 20 years the cost of manufacture has been greatly reduced, and the price charged to private consumers in this borough is to-day $1 per 1,000. There is, however, no resulting reduction to the city for street lights.
>
> . . . . . .
>
> The average price throughout the boroughs of Manhattan and The Bronx for the ordinary open-flame gas lamp is $17.45, exclusive of repairs; and, taking into account the great number of such lights, nearly 20,000 in all, and in view of the fact that the greater part of Manhattan Island was supplied with gas lamps for $17.50 twenty odd years ago, I cannot agree that the price charged to-day is reasonable.

As to the 40 miles of mains in the Bronx, mentioned just above, Mr. Monroe says that the cost thereof cannot represent 0.25% of the capitalization of the company, and that the city of New York borrows money at an average rate of 3.26%.

Regarding the cost of incandescent gas mantles, Mr. Bowers says that gas companies in New York own none; that they are patented; but that the Consolidated Gas Co. has tested incandescent burners constantly, has the Scott-Snell lamp in use in front of its offices, and is "ready to adopt, to the service of the city, any incandescent mantles or lamps the city may desire."

As to the city's claim that gas lamps with incandescent mantles in Chicago cost $18.55 each, against $29 in New York, Mr. Bowers states that the Chicago incandescent mantles are maintained by a pilot light, burning the whole 24 hours, and are merely an adoption of old flat flame burners, formed by inserting an incandescent mantle and a mica chimney, and yielding a light that "does not compare" with that from Welsbach burners.

Mr. Monroe, in return, says that the New York lights in question are 60 c. p., and the Chicago, 50 c. p.; that about 50% of all Chicago lamps have incandescent mantles, but that under present arrangements New York can afford only about 20%.

Mr. Bowers states that a year ago the Chicago South Park Board renewed a contract with the Welsbach Co. for lighting Michigan Ave. at $30 per lamp, but he does not give the candle power of the lamps. Mr. Bowers also reviews Mr. Monroe's figures on incandescent lighting in other cities, points out some alleged errors, and concludes that the Consolidated Gas Co. is really furnishing Welsbach lights at a lower price than is charged in other cities. Mr. Monroe urges that

> if the field were open in New York several independent companies would bid for mantle lights, assuming all liability for patent infringements. In the city of Baltimore an independent lighting company maintains mantle lights of 60 c. p. at a net cost to the city of Baltimore of $21.40 per lamp per year. This price is upon 6,000 lamps. With four times the number of lamps a material reduction on the Baltimore price should be secured for New York.

Mr. Monroe's original report contained electric lighting statistics from 68 American cities, showing an average cost of $88.60 per 2,000-c. p. electric lamp, as compared with the $146 paid in the borough of Manhattan. In justification of the latter figure Mr. Bowers devotes considerable space to showing how prices for private electric lighting have been voluntarily reduced in New York, which price is now 15 cts. per KW. hr., against "a maximum" of 20 cts. in Boston and Chicago. Mr. Bowers then passes to Mr. Monroe's figures for other cities, and states that some of the plants involved are operated by water power; many have less total hours of service per year; in many less current is required; in nearly all wires are overhead; and in only one instance are all the wires underground, as in New York.

To these latter criticisms Mr. Monroe replies that none of the plants in the list was reported as operated entirely by water power; that in a few instances both steam and water power were reported, but it was thought that the double equipment thus provided largely nullified the reduction in cost due to water power; that the various cities reported the lamps as burning all and every night, and that this is all New York requires; that the New York specifications call for 425 volts per 2,000-c. p. lamp, whereas the National Electric Light Association requires 450 volts per lamp; that the company represented by Mr. Bowers controls the lighting facilities in the Bronx, where the wires are overhead, but charges $146 there, also; and one would suppose that the cost of fuel, length of contract and number of lights would affect the price charged per light per year,

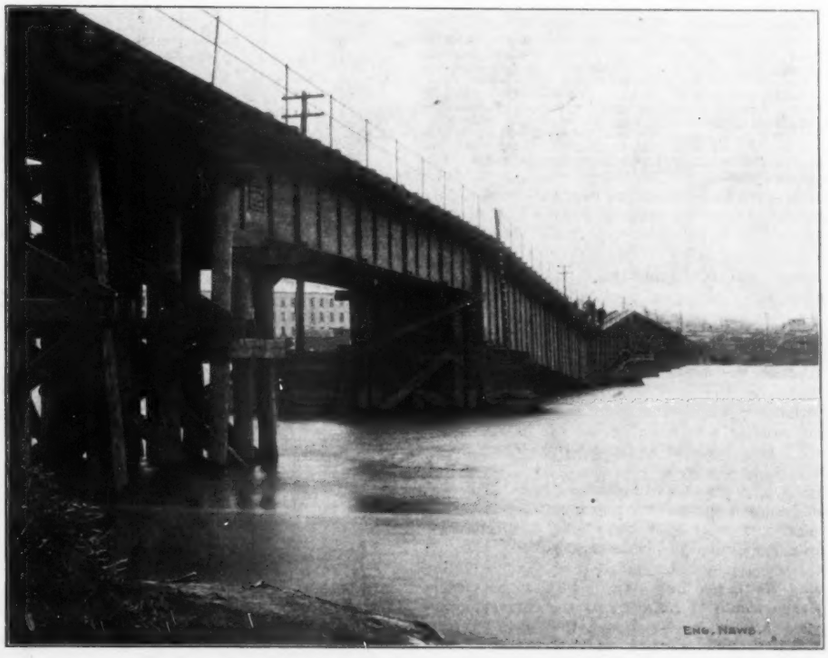

FIG. 2. VIEW OF FALLEN BRIDGE SPANS, LOOKING ACROSS THE RIVER.

but it apparently does not. . . . Each city seemed to pay what it was willing to or what it had to.

Taking 21 cities with populations of 100,000 or over, none having either water power or municipal plants, it is found that the average price per 2,000-c. p. lamp is $94.12, while for cities of 200,000 population or more the price paid is $94.12, as compared with the $88.60 for the full list of 38 cities, and the $146 paid by New York.

A large part of the balance of each paper, or discussion, is devoted to the reported cost of electric lighting in Chicago and Detroit, as furnished by the municipal plants in each city. Mr. Bowers claims that the official figures for these cities are far below the actual cost, owing to omitted items, and that after allowing for these omissions, and adding in the extra cost of the underground wires in New York, the price bid by his company, $146 per lamp, is lower than the corrected cost for the cities named. To substantiate this claim he quotes from a report on the cost of lighting in Detroit and Chicago, in 1897, made by Mr. Nathan Matthews, of Boston, and from a report on the average cost of lighting in Chicago from 1888 to 1900, inclusive, made by Haskins & Sells, expert accountants.*

Mr. Monroe objects to the use of figures for 1897, in comparison with conditions in 1902, and quotes from the Chicago municipal report for 1902, and from figures presented at the convention named in the accompanying foot note, to show that the actual cost of lighting in Chicago and Detroit is far below $146 per lamp per year.

Mr. Bowers says that the experience of Chicago and Detroit is against municipal ownership; that Boston and Worcester decided against it after careful investigations; and that the Philadelphia municipal gas plant "was conducted at such an enormous loss that the city was glad to abandon the same and lease its plant to a private corporation." Had Mr. Bowers said that the Philadelphia gas works were virtually starved and wrecked in order that they might be turned over to a private corporation he would have been nearer the truth.

In concluding his reply to the defense put forward by the attorney of the Consolidated Gas Co. Mr. Monroe says:

> But the most important facts bearing on the present situation, laid before you in my report, are not controverted nor even alluded to in the reply of the Consolidated Gas Co. It is not denied that the city of New York is at present at the mercy of a lighting combination which is able to fix prices for public lights without any competition; that the companies in control are greatly over-capitalized; that their prices are fixed to meet dividends and interest charges on such over-capitalization, and that the prices charged include excessive profits far beyond the cost of manufacture and delivery.

Mr. Monroe also points out that Mr. Bowers has given no information regarding the actual cost of electric street lighting in New York, which, as is stated in more detail in our editorial columns, is the question of first importance in this whole discussion.

*See "Municipal Affairs," March, 1902; also report of the recent municipal ownership convention, Engineering News, March 5, 1903, for adverse criticism on the Hoskins & Sells report. At the same convention the Detroit figures were also gone into in detail and some new ones given. Since this article was written the full report of the convention just named has appeared in Vol. VI., No. 4, of "Municipal Affairs."

A NOVEL CHAIN AMMUNITION HOIST.

Although the device about to be described was designed for the special purpose of raising ammunition for large guns from their magazines, it seems equally well adapted for use in any place where heavy weights are to be raised and delivered without shock.

Fig. 1 is a side elevation of a "back delivery" hoist designed for handling ammunition for a 10-in. gun, and is of sufficient capacity to continuously carry projectiles weighing 575 lbs. each on successive carriers suspended from carrier chains moving 25 ft. per min. Ordinarily, in service, a projectile would be followed by the corresponding charge of powder, which for the 10-in. gun is made up in two sections, so that under normal conditions the hoist would run with a projectile on one carrier and the two following carriers each with a half charge of powder, but as a condition might arise which would require projectiles to be sent up successively, the hoist was designed to have ample power to meet such a condition.

This hoist was first designed for handpower only, but the design was afterward changed to allow the use either of hand or electric power, as shown in Figs. 1 and 3. A 3½-HP. motor having a maximum speed of 1,400 revs. per min. drives a worm meshing with a worm wheel keyed to the sprocket wheel shaft.

There are two types of ammunition hoist, the "back delivery" and the "front delivery." The back delivery hoist, Fig. 1, is the simplest; it receives the ammunition on one side and delivers it on the other side of the chain elevator. Whenever it becomes necessary to take ammunition down, instead of up, it is only necessary to reverse the motion of the elevator and to feed the ammunition in at the top. When ammunition is being sent up, it is received on the table below and rolls between guides, shown in detail in Fig. 5. The carriers pass up between these guides and scoop up the ammunition. In a "front delivery" hoist the receiving table and delivery table are both on the front side of the elevator which necessitates a somewhat more complicated receiving table as shown in Fig. 4. The empty descending carrier strikes a guide, G, which swings the carrier out away from the chain until it escapes from the guide G, and rides down on the guide S, ready to scoop up the ammunition as shown in Fig. 4. When it becomes necessary to reverse the motion of the chain elevator in order to bring ammunition down from above, in a front delivery hoist, it is first necessary to loosen the guide S and let its lower nose rest freely upon the guide G. Then a carrier, now moving in a reverse direction, passes up along guide G, raises guide S until guide S escapes and drops back, permitting the empty carrier to ride up the guide S. Fig. 6 shows the elevator chain and method of fastening a carrier to it.

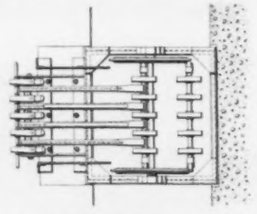

Fig. 2. Plan of Delivery Table.

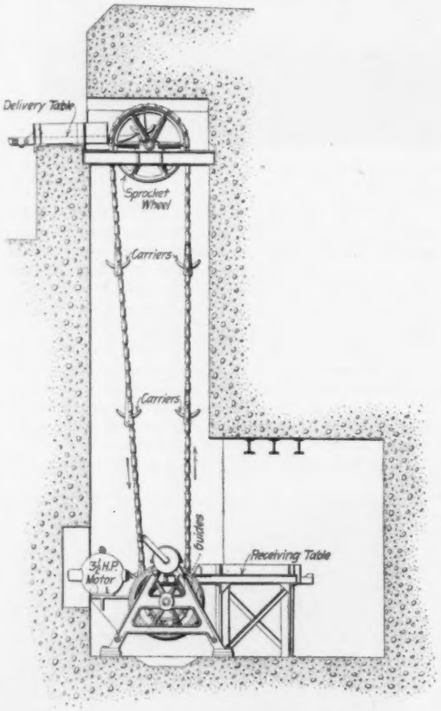

Fig. 1. Side Elevation of Back Delivery Hoist.

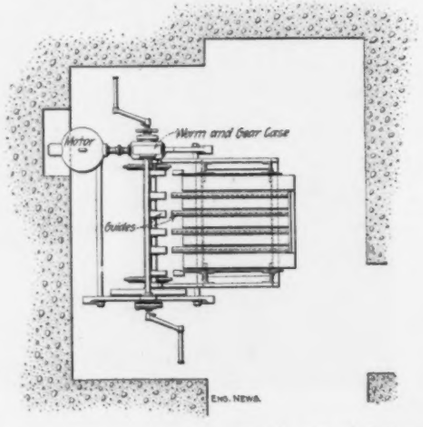

Fig. 3. Plan of Receiving Table of Back-Delivery Hoist.

For a description of this hoist and blueprints from which the accompanying cuts have been made we are indebted to Capt. Harry Taylor, Corps of Engineers, U. S. A., U. S. Engineer Office, Boston, Mass.

THE USE OF OIL ON ROADS.*

By Hiram M. Cbittenden,† Captain, Corps of Engineers, U. S. A.

The use of crude petroleum in laying dust on public highways and otherwise improving them is of very recent origin and has not yet emerged from the experimental stage. While enough has been done to give oil a definite standing among the recognized materials in future road construction, it still remains to be shown what its full possibilities are and how it can be most effectively applied. Very little has been written upon the subject, and nothing has been done, so far as the writer knows, toward its systematic and scientific investigation. Such an investigation, when made, should cover the following points:

(1) It should determine the different grades of crude petroleum, as obtained from the different oil fields of the country, and show their relative value for use in road work. Some of these oils are undoubtedly superior to others for this particular use; but as the cost of transportation will restrict the use of each grade to a comparatively limited area and make it impossible to use the best everywhere, it is important that the quality of each should be thoroughly understood, with particular reference to the character of soil in the surrounding country.

(2) The effect of oil upon different kinds of soils should be most carefully studied. It is evidently not every soil that can be successfully treated in this way. At any rate, some soils are better adapted to the use of oil than others.

(3) The best method of applying the oil should be determined by extensive experiment. A mooted question now is whether it should be applied hot or cold. The general opinion seems to be that it is better to apply it hot, but as the cost is greatly increased by this requirement, it may more than offset the advantage.

(4) The effect of oil in laying dust is not the only advantage of its use, and the question of its influence in shedding storm water and keeping the roads from becoming muddy should be determined. It is believed that herein will be found one of the most valuable features of the use of oil on dirt roads.

(5) The effect of oil on roads of different grades of construction, ranging all the way from simple earth roads to the best macadam, should be carefully studied. It is especially important to determine whether an earth road, by the use of oil, can be maintained in good condition at all seasons. There are vast areas of country in the central West where stone is not available for macadam except at great cost of transportation. If earth roads can be maintained in good condition by the use of oil at a reasonable cost, it will be an inestimable benefit to the people of those sections.

(6) Attention should be given to the relative cost of oil and water sprinkling in streets and parks, and the relative advantages of the two methods in the matter of cleanliness, etc.

In only a very general way can any of the above questions be considered as settled at the present time, and it is to be hoped that the Government Bureau of Public Roads Inquiries will, in the near future, give these full and complete investigations.

The writer recently examined the roads in the vicinity of Bakersfield, Cal., where conditions are the most favorable possible for the use of oil. There is an abundant oil field near by. The oil possesses in a high degree the par-

*From the "Report of the Chief of Engineers for 1902; Appendix 22, 'Technical Details,'"

†Officer in Charge of Improvement of Yellowstone National Park.

ticular qualities considered essential for successful road use. The soil itself is well adapted to the absorption and incorporation of the oil. It is a sandy loam of more than ordinary stability, and for light travel wears well in its natural condition. Under heavy traffic, however, it cuts badly, and the dust, before the roads were sprinkled with oil, is said to have been well nigh unendurable. Fruit trees along the leeward side of the roads are said to have been destroyed from this cause.

The use of oil on these roads has certainly been a success. As yet it is applied in only the simplest and crudest way, and no attention is paid to the ordinary maintenance of the roads. There is no systematic grading, no system of repairs, nor even any attempt, so far as the writer

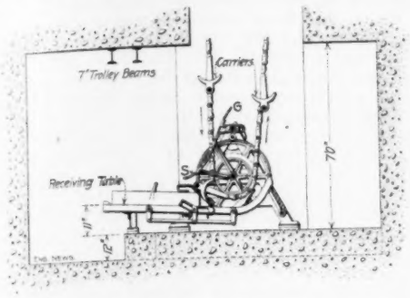

Fig. 4. Sectional Elevation of Receiving Table, Front-Delivery Hoist.

could see, to fill up ruts or chuck holes. The real benefit from the use of oil is thus largely obscured by the neglect of ordinary care of the roads. Nevertheless, the dust has been effectively laid. Roads that had not been sprinkled in two months looked as if a water sprinkler had just passed over them. It was evident that if pains were taken to crown up the surface, guard against wear, and, in short, do the ordinary work of maintenance, the addition of the oil would produce in that section of the country a road but little, if any, inferior to an asphalt pavement.

It is understood that the roads near Los Angeles have been cared for in this way and that the results are exceedingly satisfactory. The writer examined the roads in the Golden Gate Park, San Francisco, which have been treated with oil for two seasons, and certainly nothing superior to them in the line of beautiful driveways exists or can be desired.

The writer saw but little to justify the fear often expressed that the use of oil would make traveling disagreeable on account of the odor of the oil and the danger of getting the oily dust or dirt on the clothing as it is thrown up by the wheels. So far as the odor is concerned, the writer noted nothing more offensive, during an extensive drive, than what is ordinarily experienced in driving over an asphalt pavement on a hot day. The annoyance from the other cause depends entirely on the degree of absorption of the oil in the road surface. When

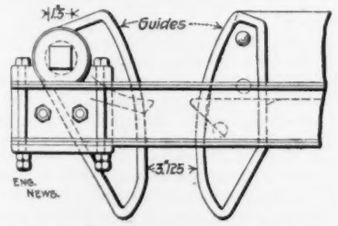

Fig. 5. Detail of Guides on Receiving Table of Back-Delivery Hoist.

first put on, if carelessly applied, there is no doubt that the imperfectly incorporated oil might be thrown about a good deal.

We may summarize as follows the results of experience to date in California in the use of oil upon public highways:

(1) This system of road improvement is rapidly becoming a recognized policy throughout that state. It is considered to offer the best, cheapest, and most satisfactory solution of the road problem. It has given complete satisfaction wherever applied.

(2) The oil is a crude petroleum with a large percentage of asphaltum, nearly free from water, and 15 to 17 degrees specific gravity, Beaumé scale.

(3) The oil works best in a sandy soil, such as prevails extensively in the valleys of California. In many instances a layer of sand from ¼-in. to 1 in. thick is put on at the time of oiling, the sand being an excellent absorbent of the oil. Clay does not absorb the oil well, and is liable to ball up and give trouble. Sand is therefore necessary on such soils to produce the best result. Sand is also used on rolling roads, for the soil being already well saturated, the new sprinkling absorbs slowly, and makes a disagreeable surface for some time afterwards. To avoid this, sand is sprinkled on the road at the same time with the oil.

(4) The use of oil must be applied with method, and not put on carelessly and left to do the work itself. The road should be carefully graded, crowned, rolled and otherwise prepared as if to receive a macadam surface. In putting on the oil the immediate surface should be scratched up skin-deep so as to facilitate absorption. The amount of this harrowing depends upon the character and quality of the surface.

(5) The best results are obtained by putting the oil on hot, in the heat of the day, and in midsummer when the road surface is warm. The oil is more active under these conditions, and is more thoroughly absorbed in the soil. If put on cold on a cold day, and with a cold soil, it is liable to ball up and be rolled off by traffic, and to absorb very imperfectly and unevenly. Good results, however, have been obtained by cold sprinkling, and the cost is about one-third less than by hot sprinkling.

Various methods have been tried and proposed for heating the oil, none of them possessing features of any special ingenuity. The writer was told at Bakersfield that heating by contact with hot surfaces was not practicable because the petroleum thickened up and became a gummy, viscous liquid. It was considered better to force steam into the oil by means of steam hose. The apparatus for heating oil is admittedly in a very crude state of development at present. The desideratum would be a steam-propeled sprinkler provided with a steam hose attachment, so that the same power which propels the sprinkler would also keep the oil hot while the sprinkler is in motion. Such an arrangement could also be combined with an automatic sand sprinkler whenever a sprinkling of sand is considered essential.

One authority states that the oil should be heated to 180 degrees for the first application, and 230 degrees for the second and subsequent ones.

(6) Plant.—Nothing especially characteristic has been developed in the line of a sprinkling plant, except that a certain patented device consists of the main oil tank (about 600 gallons capacity) followed by a two-wheeled tender provided with sprinkling jets and two sets of harrow teeth, one in front and one in rear of the jets. It is important to avoid spraying the oil lest it cool off too much, and it should be released as far as possible under uniform pressure in order to secure a uniform sprinkling and avoid waste. It is evident that there is an opening here for a practical and valuable invention, as nothing so far devised completely fills the want.

(7) The oil required for an 18-ft. roadway is variously stated by different authorities; but from experience to date we conclude that for satisfactory work the first sprinkling should be at the rate of 120 to 150 barrels per mile, the second at the rate of 70 to 80 barrels, and the third at the rate of 25 to 30 barrels. The sprinklings occur in successive seasons, and the smaller quantity would apply also to the fourth and subsequent seasons. Of course no rule of universal application can ever be formulated, for each kind of soil will have its own requirements.

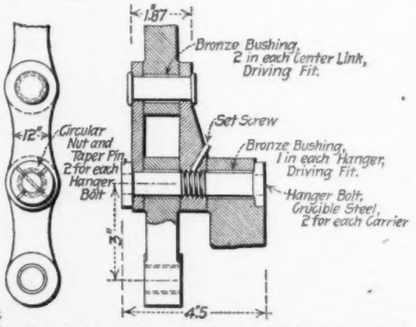
1.87
Bronze Bushing, 2 in each Center Link, Driving Fit.
Set Screw
Bronze Bushing, 1 in each Hanger, Driving Fit.
Hanger Bolt, Crucible Steel, 2 for each Carrier
1.2"
Circular Nut and Taper Pin, 2 for each Hanger Bolt
3"
4.5

Fig. 6. Elevation and Section of Elevator Chain and Carrier Attachment.

(8) The cost of oil sprinkling in any particular case will be a function of the cost of the oil and the cost of transportation. The cost of application will not vary much in different localities. Contracts have been let in Bakersfield for sprinkling with heated oil at the rate of $1 per barrel. With oil at the price it now sells at in that vicinity (about 20 cts. per barrel) the price is evidently a very profitable one to the contractor.

(9) It is fully recognized that a careful system of construction and maintenance should be combined with oil sprinkling in order that the latter may yield its best results.

[While Capt. Chittenden mentions the necessity of determining the grade of petroleum to be used on roads, he does not call attention to what now appears to be an undeniable fact, that is the fitness of oils with an asphalt base and unfitness of oils with a paraffine base. Recent experiments by the Department of Public Parks, Boston, Mass., have shown that Pennsylvania oil is a failure as a road maker. It is moreover extremely disagreeable as regards the odor that it gives off. Pennsylvania petroleum, it should be remembered, has a paraffine base. On the contrary we know that California oil is giving perfect satisfaction on soils of all kinds from sand to adobe clay. The secret of this success has been attributed by many engineers to the dry climate of California. A little thought, however, should have upset any conclusions based upon such reasoning. The real secret lies in the quality of the petroleum itself. California petroleum has an asphalt base (40%), and to this base we must unquestionably attribute its value as a road-making material of proved excellence.

At a recent convention of California's municipal officers, the City Engineer of Fresno, where streets and country roads are being oiled extensively, gave an estimate of cost at that place. The price of the petroleum there is 75 cts. per bbl., and 125 bbls. per mile are used in the first oiling, followed later in the same year with 50 or 75 bbls. more, making a total cost of $200 a mile; $100 more is expended during the following two years.

The asphalt base in California oils appears to make a crust with the earth or soil upon which it is sprinkled; and, as stated by Capt. Chittenden, there is no objectionable odor except immediately following the oil sprinkling.

It is apparent now why California oil roads are so pronounced a success, while those in the East have been a failure.—Ed.]

COST OF REPAIRING MACADAM ROADS IN MASSACHUSETTS.*

Parts of the roads in Leicester, Fitchburg, Beverly, Shrewsbury, Lowell and Lee were thoroughly resurfaced and repaired during the current year (1902). The length thus repaired was 3.44 miles. As these are the only roads that have been resurfaced since the commission began its work, it may be interesting to analyze the cost. It must be borne in mind that these are not typical state roads, but ways approaching large cities, and subject to much wear by large volumes of heavy traffic.

The Leicester road repaired is 3,150 ft. long and 24 ft. wide, and covers an area of 8,400 sq. yds. The repairs consisted of resurfacing alone. There were 659.62 tons of local stone used for the bottom course and 835.71 tons of trap rock used for the top course, a total of 1,495.33 tons. The cost of repairs was 30 cts. per sq. yd. or 5.17 cts. per sq. yd. per year. The broken stone cost $1.69 per ton in place, and the loss of stone was at the rate of .03 of a short ton per sq. yd. per year. This is one of the main streets leading into the City of Worcester, and it has a large volume of heavy traffic.

The West Fitchburg road repaired is 2,200 ft. long and 15 ft. wide, and covers an area of 3,600 sq. yds. The repairs consisted of resurfacing. There were 582.15 tons of broken stone used. The cost of repairs was 36 cts. per sq. yd., or 5.15 cts. per sq. yd. per year. The broken stone cost $2.23 per ton in place. The loss of stone was at the rate of .023 of a short ton per sq. yd. per year. This is one of the main roads leading into the City of Fitchburg, and is subjected to heavy traffic.

The Beverly road repaired is 2,150 ft. long and 18 ft. wide, and covers an area of 4,302 sq. yds. The repairs consisted of resurfacing alone. There were 716.38 tons of broken trap rock used. The cost of repairs was 30 cts. per sq. yd., or 5.2 cts. per sq. yd. per year. The broken stone cost $1.80 per ton in place. The loss of stone was at the rate of .03 of a short ton per sq. yd. per year. This is one of the main roads leading into Beverly and Salem, and it is subjected to a large volume or heavy traffic.

The repairs on the Shrewsbury, Lowell and Lee roads consisted not only of resurfacing, but of building a system of underdrains and shoulders, and generally strengthening the roads by increasing the thickness of the broken stone. A large part of this work might properly have been done when the roads were built; but it was thought not to be needed at that time, and therefore was not done. A part of the cost of the present work on these roads should be chargeable to construction and part to repairs due to legitimate wear.

This is in conformity with the general policy of the commission to experiment on certain kinds of soil, giving preference to cheaper first cost, and later to strengthen the weak parts when use develops the necessity of such strengthening.

A study of five typical state roads has been made, with reference to determining the amount of broken stone used

*Abstracted from the Tenth Annual Report of the Massachusetts Highway Commission.

in ordinary repairs, or such repairs as are required to maintain the surface of the roadway in good condition at all times until resurfacing is needed. The results are given in pounds per year for each square yard of macadam.

Table Showing Quantity of Broken Stone Used in Making Ordinary Repairs.

Towns.	Length, miles.	No. of Tons of stone.	No. of Lbs. loss per sq. yd. per year.	Material.
Goshen	1.905	100.35	1.80	Soft rock.*
Lexington, Lincoln, Concord	6.973	149.12	.98	Good stne*
West Newbury	2.222	107.55	2.00	Soft rock.*
Yarmouth, Dennis, Brewster	17.008	19.00	.06	Good stne*
North Adams, Williamstown.	3.610	219.58	2.20	Trap rock.

*Native rock and stone.

The traffic on the Goshen road is light country travel, the grades are long, and all repairs are made with stone.

The Lexington, Lincoln and Concord road has a fair amount of traffic over it. Part of the road is built of fairly good native stone and part of it of trap rock.

The West Newbury road has a fairly large traffic, the stone is soft, and there are some 6% grades.

The Warmouth-Dennis-Brewster road is at all times kept covered with sand, and it is apparently in as good condition as when first built.

The North Adams-Williamstown road has a fairly heavy traffic, and is in part built over clayey soil. There has been greater wear due to the weather conditions than on any of the other roads referred to.

The average quantity of broken stone per square yard per year on the entire 31.718 miles is .92 lb. The foregoing analysis clearly shows the small quantity of stone required to maintain a broken-stone road in a perfectly good condition.

EXPERIENCE WITH COLD-WATER PAINTS is reported by Mr. G. B. Hegardt, Asst. Engineer under Capt. W. C. Langfitt, in charge of the fortifications at the mouth of the Columbia River. The quotation is from the "Technical Details" appendix to the Report of the Chief of Engineers for 1902:

For washing the concrete walls of rooms "Zinolith" was first used. It is a bright white and does not mold, but rubs and washes off easily and is not considered superior to good whitewash. Cold-water asbestine white paint was next tried, but easily molds and becomes streaky, and is very offensive in applying and for several

A small quantity of "Lythite" cold-water paint was tried as an experiment on a concrete surface in a damp place, and after a month's application seems to be acting nicely, retaining its whiteness without molding. It is too soon, however, to determine its good or bad properties.

But where the concrete walls are so apt to be disfigured by greasy hands and clothing it would seem that a good fresh whitewash, which could frequently be applied by the troops caring for the emplacements, would be far superior to any patent washes tried.

months after application.

A PAINT SPRAYING MACHINE for use with heavy lead and oil paint as well as with lighter paint and whitewash has recently been introduced by Mr. F. E. Hook, of Hudson, Mich., in addition to his ordinary spraying or pneumatic coating machine. The nozzle is of much the same form as that used with the older machines, but instead of depending upon the nozzle to form the spray a mechanical agitator is placed in the tank and not only keeps the paint properly mixed, but also keeps it in proper condition to be readily sprayed. The air pressure in the tank is obtained by a hand pump and not from an air compressor, and when a certain pressure is reached the agitator is automatically started. The principle is different from that of the oil paint machines supplied with pressure from air compressors, in which the air is used to swell the liquid from a receptacle by an atomizing process and is also used to form a spray by arranging the air delivery so that it comes out beneath (or in some cases above) the liquid. The principle is also different from that of the ordinary hand-pump machine, in which the air is compressed in the receptacle and simply forms the means of discharging the liquid without operating the pump handle.

THE PRESERVATION OF STEEL IN CONCRETE where the latter was exposed to water and air was shown in an examination of some old Monier plates in Berlin. The plates were part of the shore protection of the River Spree; they were reinforced by a network of ¼ and ⅛-in. bars wired together at the intersections. At some points the bars came as close as ⅛-in. or less to the surface of the concrete, the maximum distance being under 1 in. Many of the plates showed damaged spots, some of which were produced by external injury, others by a cracking off of the concrete where it formed only a thin shell over the reinforcing rods. At all such injured places and in all places where there were even fine cracks in the concrete the rods showed a fair to heavy coat of rust. But the important observation was that at a number of points there was evidence that the rusting of the rods occurred before the concrete had cracked off, and had produced the latter effect; these cases all occurred where the rods came closer than about ⅝-in. to the surface of the concrete, and it was concluded that a lesser thickness than this over the metal was insufficient to protect it from rust. A further point brought out by the examination was that wherever rust was found on rods which were still fully imbedded in concrete the adhesion of the concrete was very much less than where the rods were clean.

THE TOPOGRAPHIC MAPPING of Long Island will be completed by the U. S. Geological Survey this summer.

THE LODGE-MUIRHEAD SYSTEM OF WIRELESS telegraphy has just been launched in commercial form in England. The system is based mainly on the inventions of Sir Oliver Lodge, the apparatus being worked out by him in conjunction with Dr. Muirhead. One of the principal novelties in the system is the use of a new form of coherer in the receiving apparatus. A small steel disc is rapidly rotated with its edge just above the surface of mercury contained in a small cup; a film of oil on the mercury separates the latter from the polished steel except when the film is momentarily interrupted by "cohering" between the steel and mercury. The rotation of the disc immediately "decoheres" the contact, so that no tapping is necessary. This coherer is said to be absolutely reliable and of great sensitiveness. The system also employs an automatic interrupter to break up the Morse dots and dashes as sent by an ordinary transmitter into a rapid succession of electric impulses. Sending and receiving circuits are closed circuits connected with the actual station wires by transformer coils; this arrangement, which is widely used, is said to be original with Lodge and covered by his patents.

MOVING A 110-FT STEEL CHIMNEY.

It occasionally happens that a chimney must be moved from an old site to a new one. Just how to handle so top-heavy a structure while moving it may therefore be of interest to some of our readers.

The particular stack whose moving will be described is located in Orange Valley, N. J., at the hat factory of F. Berg & Co., which was burned down last July. Its height is 110 ft., and its weight is 24,000 lbs., exclusive of a scaffolding built up inside to the top. The stack is riveted to the usual form of iron bed-plate, which in turn is anchored to the brick foundation with four bolts, one at each corner.

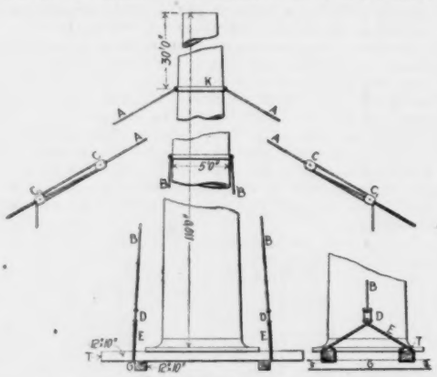

Fig. 1. Method of Guying a Chimney for Moving.

Fig. 3. Bridle Chain and Turnbuckle.

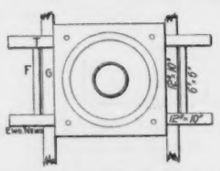

Fig. 2. Plan of Chimney and Timber Crib.

Before jacking-up the stack, the four wire-rope guy lines, A, shown in Fig. 1, were anchored to telegraph poles and neighboring buildings. Double blocks, C, were fastened to the ends of these wire ropes, and 1⅛-in. manila rope reeved through them and through the double blocks C^1, which were fastened to the anchor chains. The free end of the manila rope was then snubbed around a telegraph post or the like, so that one man on each line could pay out. Two men on each of the other two lines were required to take up the slack. From an iron collar, H, about half way up the stack, two wire ropes, B, were anchored to the timbers T, which were shoved under the stack so as to just clear the anchor bolts. To shove these timbers under, it was of course necessary to cut away part of the brick foundation. Struts, F, were then placed between the timbers T to hold them apart and a chain bridle E, shown in Fig 3, was slung around the timbers T. A turnbuckle, D, was fastened at one end to this chain bridle and at its other end to the guy line, B. It is evident that by tightening these guy lines B, by means of the turnbuckles, the timbers T were rigidly held in place, thus anchoring the stack to these timbers. The old anchor bolts were sawed off, four screwjacks were placed one under each end of the timbers T, and the stack was raised, a spirit level being used to insure keeping its base level, although the level was hardly needed, since the eye will readily perceive any tilting of so high a stack. Having raised the stack with the jacks, additional timbers T^1, Fig. 2, were placed under its bed-plate, and long cross timbers G were shoved under timbers T and T^1. A cribwork of short 12 × 12-in. and 6 × 6-in. timbers was built for these timbers G to rest upon, and all was ready for the advance. It should be stated that the contact surfaces of timbers T and G were well doped with wagon grease and soft soap, to facilitate sliding.

The power for hauling the chimney along on these skids was a horse, operating an upright capstan, having a 12-in. wooden drum and an 8-ft. sweep at the end of which was fastened the whiffle-tree. This capstan was "anchored" simply by driving four iron rods into the ground in front of the wooden cross pieces of the capstan bed frame.

Manila rope, about 1⅛ ins. diameter, was wound five times around the lower end of the capstan drum and one man held the free end of the rope and gathered it in as the horse wound it up. This rope was reeved through two three-sheave blocks having 6-in. sheaves. One of these blocks was chained to an anchorage, the other was chained to the timbers T under the chimney. An anchorage was commonly made by placing a long timber across a window on the inside of a neighboring brick building and fastening the chain to this timber.

It will be seen that the power of the horse was multiplied six times by these triple blocks. This was again multiplied about 16 times by the capstan for the sweep was about 8 ft. long and the drum was worn to about 10 or 11 ins. diameter. Thus the power of the horse was multiplied about 6 × 16 = 96 times, not considering friction of the blocks, etc. It is probable, however, that this friction reduced the effective pull by at least 40%, which still leaves ample power for sliding greased wood upon greased wood under a 12-ton weight, even with one horse. But if the wood is not greased or if it becomes wet then it is quite a different matter. It rained several times during the moving and caused a suspension of work for some time after the rain stopped; for when the wood is wet the friction is so increased that one horse cannot start the load. By hammering the timbers with mauls it was possible to start the stack moving, but due to the strain under which the hauling rope then was, the load moved with a sudden jump of six or more inches which threatened to cause overturning of the chimney. Had it not been for rain the chimney would have been moved from its old site to its new site, about 150 ft., in four days with a crew of eight men under a foreman, for 50 ft. progress was readily made on a dry day. The stack was raised several feet and turned partly around at the end of its journey to place it upon the new foundation.

Mr. L. D. Martin, of the Taylor-Martin Engineering Co., 365 Market St., Newark, N. J., has charge of the construction of the factory, which was designed by his firm, and under his direction the chimney was moved by Lewis Schonerwolf, Contractor, of Newark, N. J. The foreman, in immediate charge of the moving operations was Frank Camp. W. H. and F. W. Cane, 21 Park Row, New York City, are the contractors for the building of the factory itself.